

BRAIN INTRACRANIAL



At some point in your life, you must've experienced a lightbulb moment when an amazing idea just popped into your head out of nowhere. But what is your brain doing during these brief periods of creativity?

Researchers from the University of Utah Health and Baylor College of Medicine looked into the origin of creative thinking in the brain. They found that different parts of the brain work together to produce creative ideas, not just one particular area.

"Unlike motor function or vision, they're not dependent on one specific location in the brain," Ben Shofty, the senior author of the study and an assistant professor of neurosurgery at the Spencer Fox Eccles School of Medicine, said. "There's not a creativity cortex."

The team of researchers used a brain imaging technique that is usually meant for identifying seizures in epileptic patients. The method involves placing tiny electrodes directly in the brain. That way, scientists can accurately monitor electrical activity.

The team examined the default mode network (DMN) in the brain. This part of the brain is active when our minds are daydreaming or not focused on a specific task. Shofty believed the DMN might be important to the process of creative thinking.

A total of 13 participants undergoing invasive epilepsy monitoring were asked to engage in two different tasks. The first was a mind-wandering task that included fixating on a shape and verbalizing thoughts. In the second task, they had to think of new uses for everyday objects like cups or chairs.

The researchers observed the brain activity of the participants as they brainstormed. During the brainstorming, the DMN lit up first. It was followed by regions of the brain associated with decision-making and problem-solving.

This indicates that creative ideas originate from the DMN and then undergo evaluation by other parts of the brain.

The team also used the electrodes to temporarily block activity in certain parts of the DMN. Participants came up with less creative ideas after the brain activity was obstructed. There was no change to the other brain functions.

The finding suggests that the DMN is responsible for the quality of creativity, not the number of creative ideas.

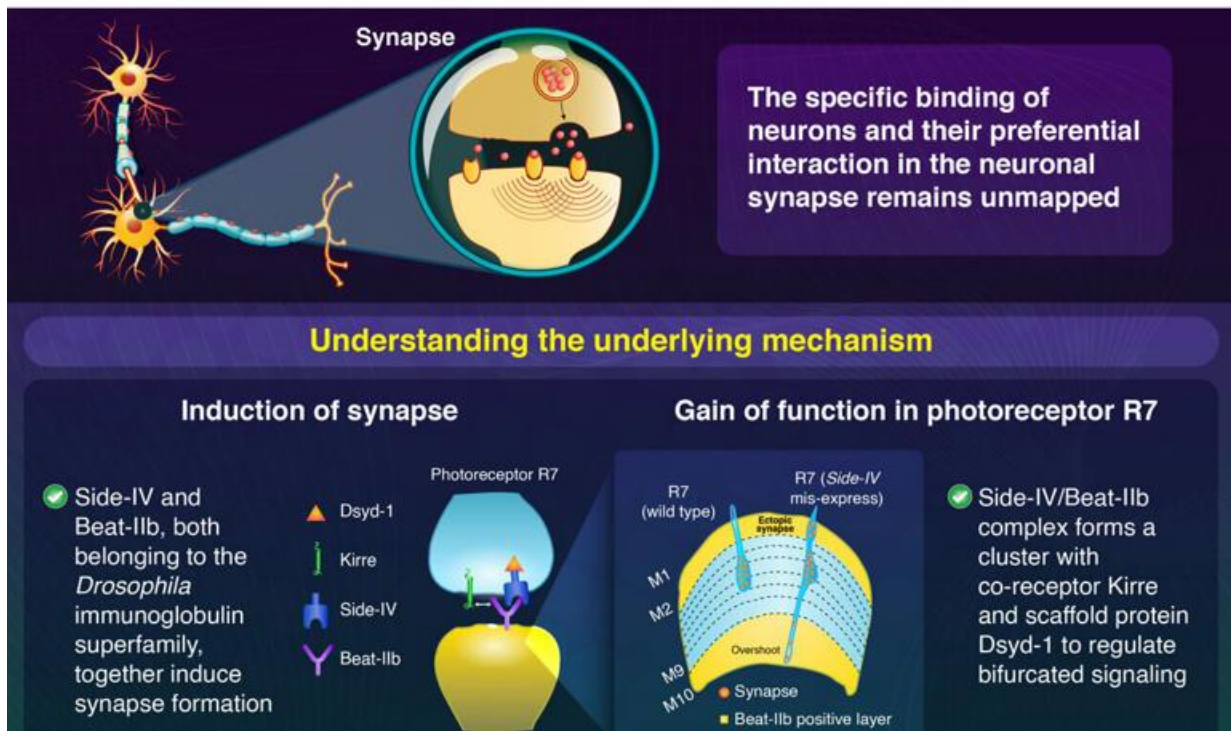
The sample size of the study was rather small, so it may not totally represent the general population. Future research could utilize a larger and more diverse sample size.

Although the study had a few limitations, it was able to provide valuable information about the brain mechanisms of creativity.

A deeper understanding of how creativity works in the brain can lead to the development of new treatments for mental health conditions that affect the DMN, like depression.

"Eventually, the goal would be to understand what happens to the network in such a way that we can potentially drive it toward being more creative," Shofty said.

Molecular Insights into the Neuronal Synaptic Interaction



This study provides insights into the molecular mechanisms underlying the neuronal synaptic interaction. Credit: Tokyo Tech© Provided by Medical Xpress

Neurons or nerve cells are the fundamental components of the central nervous system and are critically involved in signal transduction pathways. Transmission of information or signal from one neuron to another requires the establishment of a neuronal synapse: either chemical (neurotransmitters) or electrical (protein channels and ions). However, little is known about the underlying mechanism regarding the binding specificity and the ability to form preferential interactions between neuronal pairs.

In this regard, a team of researchers from Japan, led by Associate Professor Takashi Suzuki from the School of Life Science and Technology at Tokyo Institute of Technology (Tokyo Tech), recently attempted to unravel the molecular mechanisms behind the complex neuronal communication circuit.

Dr. Suzuki explains, "Take, for example, a person driving an automobile. The precise and rapid communication between the driver's perception and the locomotor system can be the difference between life and death. The appropriate functioning of the nervous system ultimately comes down to a precise synaptic interaction between different types of neurons.

"Hence, our group focused on studying the molecular mechanisms of synaptic specificity using *Drosophila*, which allowed a genotypic as well as phenotypic assessment."

The researchers employed a combination of genomic and interactome (protein–protein interactions) analyses to identify the molecular mechanisms involved in synaptic communication.

The results revealed that the specific interaction of Side-IV/Beat-IIb immunoglobulin superfamily protein molecules was responsible for inducing the formation of synapse. This combination of Side-IV/Beat-IIb was central to the synaptic specificity between neurons. Side-IV/Beat-IIb, along with Side-IV's co-receptor, Kirre, and Dsyd-1, a synaptic scaffold protein, formed a cluster to regulate a preferential signaling mechanism among neuron pairs.

The research findings were [published in *Cell Reports*](#).

Knockdown studies of synaptic scaffold protein Dsyd-1 and Liprin- α revealed the suppression of synapse formation. Moreover, Side-IV protein interaction with Dsyd-1 led to the formation of an active zone and resulted in a higher preference for synapse formation between specific neurons, thereby preventing miswiring.

Dr. Suzuki says, "We believe that our study can contribute to our current understanding of neuronal synapse and hierarchical ranking interactions among neuronal pairs. Future research involving higher order mutant species can build on our study to address the neurodegenerative disease landscape and aid in developing therapeutic strategies in the long term."

Overall, this study sheds valuable light on the molecular intricacies of neuronal communication.

More information: Jiro Osaka et al, Complex formation of immunoglobulin superfamily molecules Side-IV and Beat-IIb regulates synaptic specificity, *Cell Reports* (2024). DOI: [10.1016/j.celrep.2024.113798](https://doi.org/10.1016/j.celrep.2024.113798)

Provided by Tokyo Institute of Technology

The Institute of Neurosciences (IN), a joint center of the Spanish National Research Council (CSIC) and the Miguel Hernández University (UMH) of Elche, leads, together with Keio University in Tokyo, a study that demonstrates the crucial role of one of the receptors for the neurotransmitter glutamate in the functioning of the synapses of the cerebellum.

The work published in the journal *Cell Reports* describes the molecular mechanism by which kainate receptors act as synaptic receptors and as 'scaffolds' that support the structure of connections between neurons.

These results enable the design of new synaptic connectors using specific combinations of kainate receptor subunits and offer promising avenues for future therapeutic applications.

Synapses are the connection points where neurons establish contact with each other to transmit information. For this communication to occur, the presynaptic neuron releases a neurotransmitter, which is then received by a postsynaptic neuron.

The Synaptic Physiology laboratory directed by CSIC researcher Juan Lerma at the IN has extensively investigated glutamate receptors, which are neurotransmitters involved in various processes of the central nervous system, particularly kainate receptors, one of the three families of glutamate receptors that mediate communication between neurons.

"For many years, we have tried to find out what the function of kainate receptors is in synaptic physiology and brain pathologies," says the researcher.

His laboratory has made significant contributions to understanding the roles of these proteins in synaptic communication, which, when dysfunctional, lead to multiple neurological and neuropsychiatric disorders.

This team of IN researchers had previously detected the role that the GluK4 protein, one of the five subunits that make up kainate receptors, can play when it is overexpressed in pathologies such as autism, depression, and anxiety. They also demonstrated that the GluK1 protein is triplicated in patients with Down Syndrome and that these decompensated levels are responsible for the spatial memory deficits observed in these patients.

Furthermore, the laboratory directed by Michisuke Yuzaki in the Department of Neurophysiology at the Keio University School of Medicine in Tokyo has studied the functioning of synapses in the cerebellum over the years and discovered that an interaction between the C1ql1 and Gai3 proteins occurs in this region to enable the formation of synapses.

However, the results of this new study modify this concept by demonstrating that without the interaction of both proteins with kainate receptors, synapses do not form: "By combining our experience and knowledge in this new collaboration, we have been able to completely redefine synapse formation in the cerebellum," says Yuzaki.

The experts confirmed that the presence of GluK4, which is expressed by cerebellar Purkinje neurons, is essential for the interaction that supports synaptic transmission between climbing fibers and these neurons to occur. To confirm this, the researchers used mouse models in which they genetically manipulated the expression of these proteins.

Experiments were carried out both in Lerma's laboratory in Alicante and in Yuzaki's in Tokyo and show that in the cerebellum, synaptic plasticity, necessary for motor learning, is seriously affected when either of these kainate receptors is suppressed, both being necessary for synapse formation.

Impacts of synaptic plasticity failure

Ana Valero Paternain, the co-first author of the study, explains, "Synaptic plasticity is the brain's ability to form connections and modulate them depending on its needs. When plasticity fails, serious motor defects occur."

"In the laboratory, we have verified that when the number of synapses is reduced, mice are not able to learn motor behaviors," says Wataru Kakegawa, the other co-first author of the article.

Synthetic synaptic connectors modeled after analogous proteins have shown promise for restoring damaged synapses in mouse models of Alzheimer's disease and spinal cord injuries. Therefore, the results raise promising avenues for future therapeutic applications.

You might call it 'flow state' or 'being in the zone.' Would you be interested to learn how to make it happen?

This is a story about [creativity](#), [productivity](#), and [neuroscience](#).

In 1990, a psychologist named Mihaly Csikszentmihalyi published a book in which he described "flow," a state of mind in which people can focus their brains, shut out distractions, and become much more productive.

Maybe you think of this as being "in the zone." People have spent entire careers trying to explain, analyze, and ultimately teach others how to enter into this kind of flow state.

Now, researchers out of [Drexel University](#) in Philadelphia say they've succeeded in using neuroimaging technology to track flow state in people's brains in real time -- and maybe unlock some practical advice on how to make it happen.

Writing in the journal [Neuropsychologia](#), the researchers said they set out to consider two theories of how flow state might work:

- Theory 1 suggests that flow state might simply be, "a state of highly focused concentration or hyperfocus that shuts out extraneous thoughts and other distractions to enable superior performance on a task."
- Theory 2, however, suggests something a bit more active: The idea that through years of intense practice, people's brains can develop "a specialized network or circuit to automatically produce a specific type of ideas... with little conscious effort."

If the second theory were correct, the researchers hypothesized, this might mean that the brains of people who develop a certain level of expertise in a creative discipline might be able to "rela[x] its supervision" and basically go on autopilot - flow state, almost on demand -- exploring and creating without active control.

"Csikszentmihalyi... defined [flow] as 'a state in which people are so involved in an activity that nothing else seems to matter,' " said lead researcher John Kounios. "[T]he experience is so enjoyable that people will continue to do it even at great cost, for the sheer sake of doing it."

The Drexel experiment involved recruiting a group of 32 jazz guitarists, some of whom were highly experienced and others who were less so, and recording high-density electroencephalograms (EEGs) while they each improvised six jazz sessions, "with programmed drums, bass, and piano accompaniment."

Afterward, their performances were assessed both by (a) asking the guitarists to rate how intensely they felt they achieved a "flow state" while playing, and (b) asking four jazz experts to listen individually to each of the 192 total recorded improv sessions, and rate them for creativity and other qualities.

In the end, they made two very interesting findings:

- First, the more experienced musicians reached a flow state "more often and more intense experienced colleagues -- thus suggesting support for "Theory 2," above.
- Second, they found that the EEGs mapping the brain activity of musicians who managed to achieve a high state of flow had two marked differences from other occasions: *increased* brain activity in the left hemisphere, in areas associated with "hearing and playing music," and *decreased* activity in the *superior frontal gyri*, which is associated with executive control.

What I really like about this effort is that Kounios was willing to make a few recommendations for creative people in any field who might want to increase the odds of attaining flow state.

In short, he said it involves building deep expertise in whatever creative discipline you care for, and then also practicing and also learning how to "withdraw conscious control" once you've reached that high level of expertise.

As I write in my free e-book, [Neuroscience: 13 Ways to Understand and Train Your Brain for Life](#), there's nothing more fascinating than the human brain and the unexpected ways in which it works. Techniques like this to improve focus are at the top of the list.

Or to quote Kounios once more: "As jazz great Charlie Parker said, 'You've got to learn your instrument. Then, you practice, practice, practice. And then, when you finally get up there on the bandstand, forget all that and just wail.'"L

aryam Shanechi and her team have developed a new machine learning method that reveals surprisingly consistent intrinsic brain patterns across different subjects by disentangling these patterns from the effect of visual inputs. The work has been published in the [Proceedings of the National Academy of Sciences](#).

When performing various everyday movement behaviors, such as reaching for a book, our brain has to take in information, often in the form of visual input—for example, seeing where the book is. Our brain then has to process this information internally to coordinate the activity of our muscles and perform the movement.

But how do millions of neurons in our brain perform such a task? Answering this question requires studying the neurons' collective activity patterns, but doing so while disentangling the effect of input from the neurons' intrinsic (aka internal) processes, whether movement-relevant or not.

That's what Shanechi, her Ph.D. student Parsa Vahidi, and a research associate in her lab, Omid Sani, did by developing a new machine-learning method that models neural activity while considering both movement behavior and sensory input.

"Prior methods for analyzing brain data have either considered neural activity and input but not behavior, or considered neural activity and behavior but not input," Shanechi said.

"We developed a method that can consider all three signals—neural activity, behavior, and input—when extracting hidden brain patterns. This allowed us to not only disentangle input-related and intrinsic neural patterns, but also separate out which intrinsic patterns were related to movement behavior and which were not."

Shanechi and her team used this method to study three publicly available datasets, during which three different subjects performed one of two distinct movement tasks, consisting of moving a cursor on a computer screen over a grid or moving it sequentially to random locations.

"When using methods that did not consider all three signals, the patterns found in neural activity of these three subjects looked different," Vahidi said. But when the team used the new method to consider all three signals, a remarkably consistent hidden pattern emerged from neural activity of all three subjects that was relevant to movement. This similarity was despite the fact that the tasks performed by the three subjects were also different.

"In addition to revealing this new consistent pattern, the method also improved the prediction of neural activity and behavior compared to when all three signals were not considered during machine learning, as in prior work," Sani said. "The new method enables researchers to more accurately model neural and behavioral data by accounting for various measured inputs to the brain, such as sensory inputs as in this work, electrical or optogenetic stimulation, or even input from different brain areas."

This method and the discovered pattern can help us understand how our brains perform movements, guided by the information we receive from the external world. Further, by modeling the effect of input and separating out intrinsic patterns that are behavior-relevant, this method can help develop future brain-computer interfaces that regulate abnormal brain patterns in disorders such as major depression by optimizing external inputs such as deep brain stimulation therapy.

"We are excited about how this algorithm could facilitate both scientific discoveries and the development of future neurotechnologies for millions of patients with neurological or neuropsychiatric disorders," Shanechi said.

More information: Parsa Vahidi et al, Modeling and dissociation of intrinsic and input-driven neural population dynamics underlying behavior, *Proceedings of the National Academy of Sciences* (2024). DOI: [10.1073/pnas.2212887121](https://doi.org/10.1073/pnas.2212887121)

Provided by University of Southern California

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New research using magnetic fields shows potential for manipulating brain function, offering hope for future treatments of neurological disorders. © OsakaWayne Studios - Getty Images

- Inspired by the field of optogenetics, which controls certain genetically altered neurons with light, South Korean scientists have employed a similar technique using magnetic fields.
- In a series of tests, scientists were able to control a mouse's feeding, sociability, and parental behavior by manipulating certain regions of the lateral hypothalamus.
- This technique could prove useful in treating debilitating neurological disorders or possibly improve results in the already-burgeoning field of transcranial magnetic stimulation.

When people answer the age-old inquiry of what super power they'd want, mind control usually ranks pretty high. Now scientists from the Institute for Basic Science (IBS) and Yonsei University in South Korea are taking a big step toward making that hypothetical a bit more real by using [magnetic fields](#) to control [mice](#).

And this isn't just to improve on some impressive piece of a Professor X cosplay—the breakthrough could one day help scientists understand high [brain](#) function in humans while solving some of our greatest mental health challenges.

To create this sci-fi-esque technology, the team developed a Magnetogenetic Interface for NeuroDynamics, or Nano-MIND, device, designed to manipulate particular regions of the [brain](#) related to cognition, emotion, and motivation. At its most basic, this technique—known as magnetogenetics—uses nanoparticle switches that can essentially turn on and off via noninvasive magnetic fields, allowing control of certain rudimentary brain functions. The results of the study were published in the journal [Nature Nanotechnology](#).

"This is the world's first technology to freely control specific brain regions using magnetic fields," director of the IBS Center for Nanomedicine Jinwoo Cheon, a co-author of the study, [said in a press statement](#). "We expect it to be widely used in research to understand brain functions, sophisticated artificial neural networks, two-way brain-computer interface technologies, and new treatments for neurological disorders."

Using magnetic stimulation for therapeutic purposes isn't new, but trying to gain a quantifiable amount of specific mind control certainly is, and to achieve this world first, IBS scientists first targeted receptors within the brain's lateral hypothalamus, a region closely associated with eating and reward behaviors.

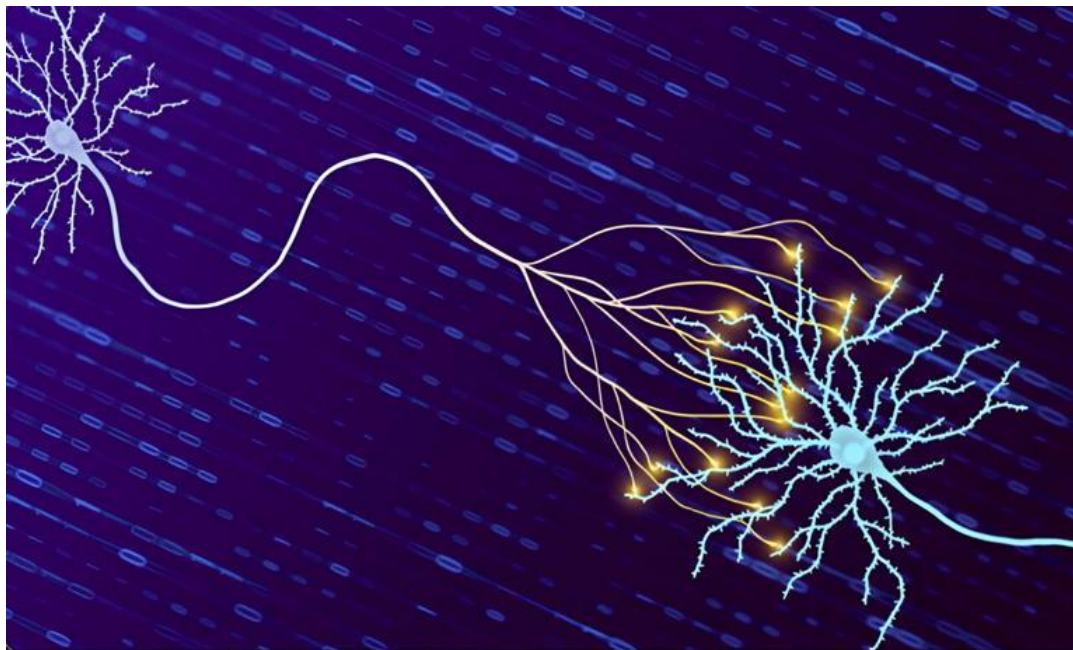
According to the researchers, when mice entered the magnetic field with switches on their excitatory neurons, this led to a 50 percent reduction in feeding behaviors while the same switches on inhibitory neurons increased nomming by 100 percent. Similar tests in the lateral hypothalamus also influenced particular social behaviors as a mouse under magnetic field influence became more friendly toward other, unknown mice.

Finally, the team conducted tests targeted at the medial preoptic area, another brain region of the hypothalamus that's closely associated with [parental care](#).

Results showed that a Nano-MIND-implanted mouse responded more directly to the cries of mouse pups than those not under any sort of magnetic influence.

This field of magnetogenetics derives directly from previous experiments employing optogenetic techniques. In 2016 [scientists at Stanford University](#) implanted LED lights (hence *optogenetics*) on nerves found in a mouse's head and right leg. Similarly, this technique could "turn on" genetically altered neurons designed to respond to flashes of light. Meanwhile, [transcranial magnetic stimulation](#) (TMS) has already shown promises in relieving symptoms of severe depression in humans, and while a medical intervention such as a Nano-MIND device is a bit more complex, the technique could one day provide similar therapeutic results for a variety of human neural disorders.

Of course, altering a mouse brain is a bit different than the incredibly complex neural landscape found in the human brain—after all, a mouse brain contains only 75 million neurons, whereas a human brain clocks in at 86 *billion*.

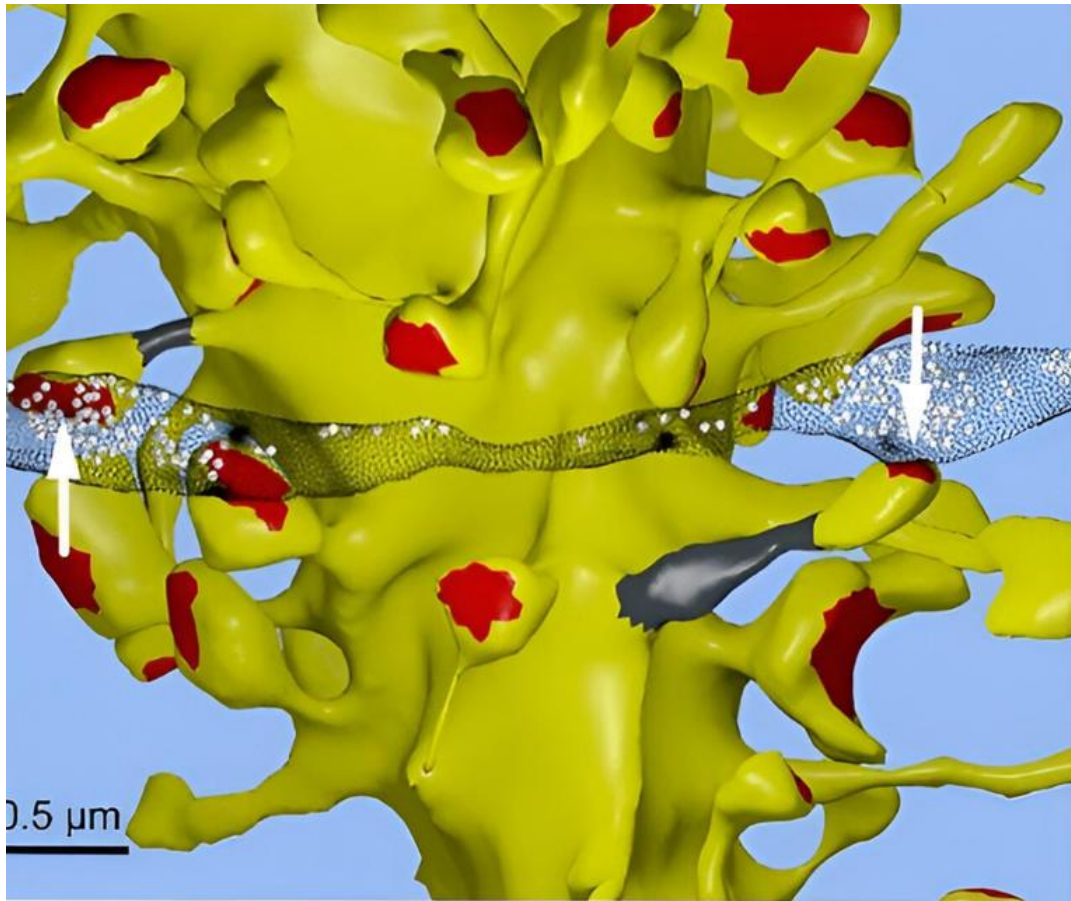


Two neurons, one in full (left, light purple) and one partially out of frame (right, light blue) on top of a background of zeros and ones to symbolize the unit of bits used to quantify information storage in synapses. The neuron on the left is sending messages to the neuron on the right. The electrical pulse of synapses processing and sending information is represented by flashes of yellow where the two neurons meet. Credit: Salk Institute© Provided by Medical Xpress

With each flip you make through a deck of vocabulary word flashcards, their definitions come more quickly, more easily. This process of learning and remembering new information strengthens important connections in your brain. Recalling those new words and definitions more easily with practice is evidence that those neural connections, called synapses, can grow stronger or weaker over time—a feature known as synaptic plasticity.

Quantifying the dynamics of individual synapses can be a challenge for neuroscientists, but recent computational innovations from the Salk Institute may be changing that—and revealing new insights about the brain along the way.

To understand how the brain learns and retains information, scientists try to quantify how much stronger a synapse has gotten through learning, and how much stronger it can get. Synaptic strength can be measured by looking at the physical characteristics of synapses, but it's much more difficult to measure the precision of plasticity (whether synapses grow weaker or stronger by a consistent amount) and the amount of information a synapse can store.



White arrows pointing at two synapses (red) on the same dendrite (yellow), sharing the same axon (spotted black tube). Credit: Salk Institute© Provided by Medical Xpress

Salk scientists have established a new method to explore synaptic strength, precision of plasticity, and amount of information storage. Quantifying these three synaptic features can improve scientific understanding of how humans learn and remember, as well as how those processes evolve over time or deteriorate with age or disease. The [findings](#) were published in *Neural Computation* on April 23, 2024.

"We're getting better at identifying exactly where and how individual neurons are connected to each other, but we still have a lot to learn about the dynamics of those connections," says Professor Terrence Sejnowski, senior author of the study and holder of the Francis Crick Chair at Salk.

"We have now created a technique for studying the strength of synapses, the precision with which neurons modulate that strength, and the amount of information synapses are capable of storing—leading us to find that our brain can store 10 times more information than we previously thought."

When a message travels through the brain, it hops from neuron to neuron, flowing from the end of one neuron into the outstretched tendrils, called dendrites, of another. Each dendrite on a neuron is covered with tiny bulbous appendages, called dendritic spines, and at the end of each dendritic spine is the synapse—a tiny space where the two cells meet, and an electrochemical signal is transmitted. Different synapses are activated to send different messages.

Some messages activate pairs of synapses, which live near one another on the same dendrite. These synapse pairs are a fantastic research tool—if two synapses have identical activation histories, scientists can compare the strength of those synapses to draw conclusions about the precision of plasticity.

Since the same type and amount of information has passed through these two synapses, did they each change in strength by the same amount? If so, their precision of plasticity is high.

The Salk team applied concepts from information theory to analyze synapse pairs from a rat hippocampus—a part of the brain involved in learning and memory—for strength, plasticity, and precision of plasticity.

Information theory is a sophisticated mathematical way of understanding information processing as an input traveling through a noisy channel and being reconstructed on the other end.

Crucially, unlike methods used in the past, information theory accounts for the noisiness of the brain's many signals and cells, in addition to offering a discrete unit of information—a bit—to measure the amount of information stored at a synapse.

"We divided up synapses by strength, of which there were 24 possible categories, then compared special synapse pairs to determine how precisely each synapses' strength is modulated," says Mohammad Samavat, first author of the study and a postdoctoral researcher in Sejnowski's lab.

"We were excited to find that the pairs had very similar dendritic spine sizes and synaptic strengths, meaning the brain is highly precise when it makes synapses weaker or stronger over time."

In addition to noting the similarities in synapse strength within these pairs, which translates to a high level of precision of plasticity, the team also measured the amount of information held in each of the 24 strength categories. Despite differences in the size of each dendritic spine, each of the 24 synaptic strength categories held a similar amount (between 4.1 and 4.6 bits) of information.

Compared to older techniques, this new approach using information theory is (1) more thorough, accounting for 10 times more information storage in the brain than was previously assumed, and (2) scalable, meaning it can be applied to diverse and large datasets to gather information about other synapses.

"This technique is going to be a tremendous help for neuroscientists," says Kristen Harris, a professor at the University of Texas at Austin and an author of the study. "Having this detailed look into synaptic strength and plasticity could really propel research on learning and memory, and we can use it to explore these processes in all different parts of human brains, animal brains, young brains, and old brains."

Sejnowski says future work by projects like the National Institutes of Health's BRAIN Initiative, which established a [human brain cell atlas](#) in October 2023, will benefit from this new tool.

In addition to scientists who catalog brain cell types and behaviors, the technique is exciting for those studying when information storage goes awry—like in Alzheimer's disease.

In years to come, researchers around the world could use this technique to make exciting discoveries about the human brain's ability to learn new skills, remember day-to-day actions, and store information short- and long-term.

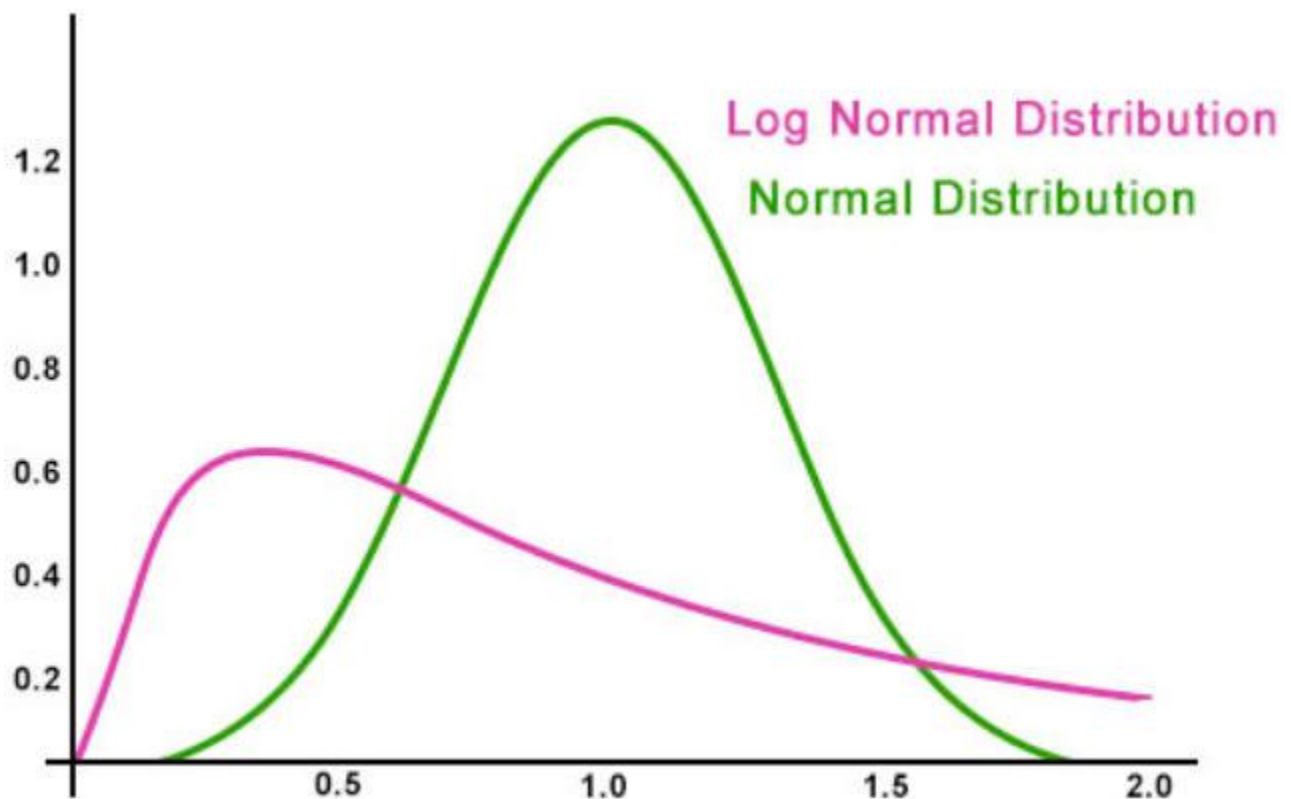
Researchers taking part in the Human Brain Project have identified a mathematical rule that governs the distribution of neurons in our brains.

The rule predicts how neurons are distributed in different parts of the brain, and could help scientists create precise models to understand how the brain works and develop new treatments for neurological diseases.

In the wonderful world of statistics, if you consider any continuous [random variable](#), the [logarithm](#) of that variable will often follow what's known as a lognormal distribution. Defined by the mean and standard deviation, it can be visualized as a [bell-shaped curve](#), only with the curve being wider than what you'd find in a normal distribution.

A team of researchers from the Jülich Research Center and the University of Cologne in Germany found the number of neurons in areas of the outer layer of neural tissue in different mammals fits a [lognormal distribution](#).

Mathematics aside, a simple and important distinction is the symmetry of the normal distribution bell curve and the asymmetry and heavy right-skewed tail of the lognormal distribution, due to a large number of small values and a few significantly large values.



An illustration of lognormal distribution and normal distribution. (WallStreetMojo)© Provided by ScienceAlert

The size of a population across a country is often lognormally distributed, with a few very large cities and many small towns and villages.

Brain structure and function depend on neuron numbers and arrangement. The density of neurons in different regions and layers of that outer tissue layer – the [cerebral cortex](#) – varies considerably.

"The distribution of neuron densities influences the network connectivity," [says](#) neuroscientist Sacha van Albada of the Jülich Research Center.

"For instance, if the density of synapses is constant, regions with lower neuron density will receive more synapses per neuron."

The statistical distributions of neuron densities are still largely unknown, though research has certainly provided us with fascinating [discoveries about our brain's cellular tissues](#).

To conduct their research, the team used nine open-source datasets covering seven different species: mouse, marmoset, macaque, galago, owl monkey, baboon, and human. When the neuron densities in different regions of the cortex were compared, a common pattern of a lognormal distribution emerged.

Neuron densities in areas of the cortex follow a consistent distribution pattern. (Morales-Gregorio)© Provided by ScienceAlert

"Our results are in agreement with the observation that surprisingly many characteristics of the brain follow lognormal distributions," the authors [write in their paper](#).

A lognormal distribution is a natural result of processes that multiply, just like normal distribution is a natural result of adding up many independent variables.

"One reason why it may be very common in nature is because it emerges when taking the product of many independent variables," [says](#) Alexander van Meegen, who co-led the research as part of his PhD in computational neuroscience at the Jülich Research Centre.

The researchers say the way the cortex is structured could be a byproduct of development or evolution that has nothing to do with computation.

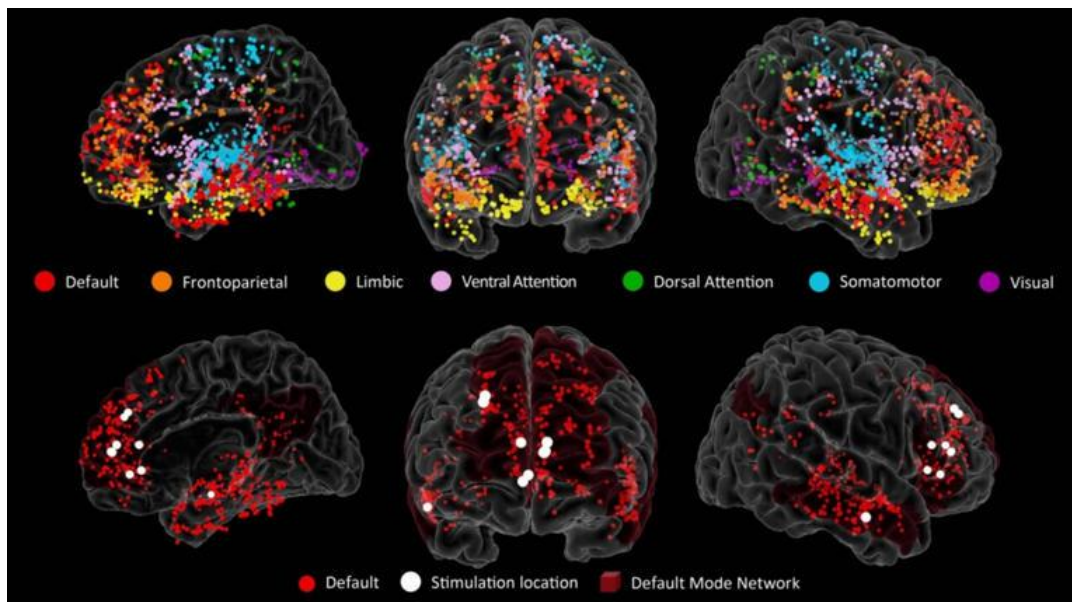
But [previous research](#) suggests brain neural network variation is more than just a byproduct and may actively help animals learn in changing environments. And the fact that the same organization can be seen in different species and in most

parts of the cortex suggests that the lognormal distribution is used for something.

"We cannot be sure how the lognormal distribution of neuron densities will influence brain function, but it will likely be associated with high network heterogeneity, which may be computationally beneficial," [explains](#) co-lead author Aitor Morales-Gregorio, a computational neuroscientist at the Jülich Research Centre.

Scientists hope this discovery will shed light on how the brain stores and retrieves information, as well as how it acquires new knowledge. In the [ongoing quest to find effective treatments](#) for brain disease, it may pave the way for the creation of new drugs that target specific regions of the brain.

The [Human Brain Project](#)'s ten-year effort to establish a shared research infrastructure for boosting neuroscience, computing, and brain-related medicine is coming to a close, and it's given us some [interesting discoveries](#) along the way.



Electrodes at multiple brain regions reveal brain activity in real time. Colored dots show the locations of all of the electrodes across all patients, color-coded by brain region. Red dots in the lower images show the locations of the electrodes in the DMN. Credit: Brain (2024). DOI: 10.1093/brain/awae199© Provided by Medical Xpress

Have you ever had the solution for a tough problem suddenly hit you when you're thinking about something entirely different? Creative thought is a hallmark of humanity, but it's an ephemeral, almost paradoxical ability, striking unexpectedly when it's not sought out.

And the neurological source of creativity—what's going on in our brains when we think outside the box—is similarly elusive.

But now, a research team led by a University of Utah Health researcher and based in Baylor College of Medicine has used a precise method of brain imaging to unveil how different parts of the brain work together in order to produce creative thought.

[Their findings published](#) in *Brain* on June 18.

The new results could ultimately help lead to interventions that spark creative thought or aid people who have mental illnesses that disrupt these regions of the brain.

Outside the box

Higher cognitive processes like creativity are especially hard to study. "Unlike motor function or vision, they're not dependent on one specific location in the brain," says Ben Shofty, MD, Ph.D., assistant professor of neurosurgery in the Spencer Fox Eccles School of Medicine and senior author on the paper. "There's not a creativity cortex."

But there's evidence that creativity is a distinct brain function. Localized brain injury caused by stroke can lead to changes in creative ability—both positive and negative. That discovery suggests that narrowing down the neurological basis of creativity is possible.

Shofty suspected that creative thought might rely strongly on parts of the brain that are also activated during meditation, daydreaming, and other internally

focused types of thinking. This network of brain cells is the default mode network (DMN), so called because it's associated with the "default" patterns of thought that happen in the absence of specific mental tasks.

"Unlike most of the functions that we have in the brain, it's not goal-directed," Shofty says. "It's a network that basically operates all the time and maintains our spontaneous stream of consciousness."

The DMN is spread out across many dispersed brain regions, making it more difficult to track its activity in real time. The researchers had to use an advanced method of brain activity imaging to understand what the network was doing moment-to-moment during creative thought. In a strategy most commonly used to pinpoint the location of seizures in patients with severe epilepsy, tiny electrodes are implanted in the brain to precisely track the electrical activity of multiple brain regions.

Participants in the study were already undergoing this kind of seizure monitoring, which meant that the research team could also use the electrodes to measure brain activity during creative thinking. This provided a much more detailed picture of the neural basis of creativity than researchers had been able to capture before.

"We could see what's happening within the first few milliseconds of attempting to perform creative thinking," Shofty says.

Two steps toward originality

The researchers saw that during a creative thinking task in which participants were asked to list novel uses for an everyday item, like a chair or a cup, the DMN lit up with activity first. Then, its activity synchronized with other regions in the brain, including ones involved in complex problem-solving and decision-making. Shofty believes this means that creative ideas originate in the DMN before being evaluated by other regions.

What's more, the researchers were able to show that parts of the network are required specifically for creative thought. When the researchers used the electrodes to temporarily dampen the activity of particular regions of the DMN,

people brainstormed uses for the items they saw that were less creative. Their other brain functions, like mind wandering, remained perfectly normal.

Eleonora Bartoli, Ph.D., assistant professor of neurosurgery at Baylor College of Medicine and co-first author on the paper, explains that this result shows that creativity isn't just associated with the network but fundamentally depends on it.

"We moved beyond correlational evidence by using direct brain stimulation," she says. "Our findings highlight the causal role of the DMN in creative thinking."

The activity of the network is changed in several disorders, such as ruminative depression, in which the DMN is more active than normal, possibly related to increased dwelling on negative internally directed thoughts. Shofty says that a better understanding of how the network operates normally may lead to better treatments for people with such conditions.

By characterizing the brain regions involved in creative thought, Shofty hopes to ultimately inspire interventions that can help spark creativity. Shofty says, "Eventually, the goal would be to understand what happens to the network in such a way that we can potentially drive it toward being more creative."



Brain creates multiple copies of single memory for robust storage

Aiming to comprehend the dynamics of memory in brains, scientists conducted a new study on mouse models and examined how memories are stored and modified in the hippocampus.

The hippocampus is a tiny, complex structure of the brain that plays an important role in learning, memory, and emotions.

Researchers from the University of Basel in Basel, Switzerland, found that memories of specific experiences are stored in the brain as multiple parallel copies distributed across a minimum of three different clusters of neurons.

These clusters emerge at different stages during embryonic development. The copies vary in terms of their duration, modifiability, and susceptibility to deletion over time.

Dynamics of memory preserves in the brain

Scientists sought to learn the dynamics of the [brain](#), which preserves and adapts [memories](#), to understand how these processes contribute to learning from past experiences and decision-making in changing environments.

The research team showed that the activation and timing of specific memory copies can significantly impact how we recall, modify, and utilize our memories.

Flavio Donato from the University of Basel explained in an official statement that the brain faces impressive challenges concerning memory.

“On one hand, it must remember what happened in the past, to help us make sense of the world we live in. On the other, it needs to adapt to changes happening all around us, and so must our memories, to help us make appropriate choices for our future,” says Donato.

Understanding how past experiences impact decision-making could be vital because memories help living beings learn from the past and adapt to changing circumstances, thus influencing future decisions and behavior.

Scientists also note that until the discovery of multiple memory copies, the mechanism behind the brain regulating a memory's dynamics remained a mystery.

Parallel copies of stored memories

Upon studying the hippocampus in mice, the team observed that parallel copies of [stored memories](#) in neuron clusters emerged at different phases during embryonic development.

These copies vary in their accessibility over time, with early-born neurons maintaining long-term memories that become accessible only after some time, while late-born neurons store memories that are strong initially but fade over time. Middle-stage neurons store more stable memories.

"How dynamically memories are stored in the brain is proof of the brain's plasticity, which underpins its enormous memory capacity," stated first author Vilde Kveim.

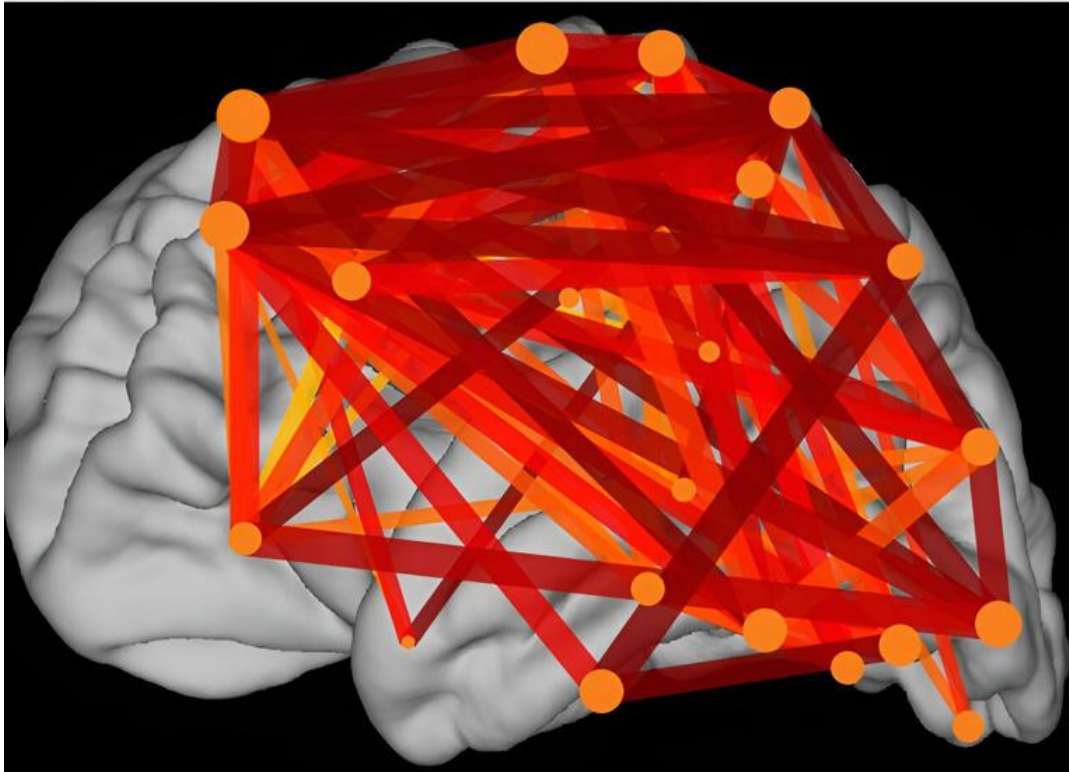
This flexibility in memory storage explains how our brain can adapt memories over time, helping us learn from new experiences while still holding on to important long-term memories.

A statement by the researchers emphasizes that persistence through dynamics is a delicate act to balance, one for which they might now have an entry point to fully understand.

This finding could potentially help scientists treat issues such as traumatic memories that might be too overwhelming or intense for an individual to manage.

It could also aid in recovering memories that have faded or seem lost, offering new ways to manage and improve mental health.

Researchers are now aiming to understand the driving force behind how memories are encoded and modified in the brain, potentially leading to ways to alleviate the impact of intrusive memories.



The lines on this diagram of the brain represent connections between various areas of the cerebral cortex involved in language processing. When we read, the neurons in these areas fire in precise synchronicity, a phenomenon known as "co-rippling." Credit: UC San Diego Health Sciences

For decades, scientists have focused on how the brain processes information in a hierarchical manner, with different brain areas specialized for different tasks. However, how these areas communicate and integrate information to form a coherent whole has remained a mystery.

Now, researchers at University of California San Diego School of Medicine have brought us closer to solving it by observing how neurons synchronize across the human brain while reading. The findings are published in [Nature Human Behavior](#) and are also the basis of a thesis by UC San Diego School of Medicine doctoral candidate Jacob Garrett.

"How the activity of the brain relates to the subjective experience of consciousness is one of the fundamental unanswered questions in modern

neuroscience," said study senior author Eric Halgren, Ph.D., professor in the Departments of Neurosciences and Radiology at UC San Diego School of Medicine.

"If you think about what happens when you read text, something in the brain has to turn that series of lines into a word and then associate it with an idea or an object. Our findings support the theory that this is accomplished by many different areas of the brain activating in sync."

This synchronization of different brain areas, called "co-rippling," is thought to be essential for binding different pieces of information together to form a coherent whole. In rodents, co-rippling has been observed in the hippocampus, the part of the brain that encodes memories. In humans, Halgren and his colleagues [previously observed](#) that co-rippling also occurs across the entire cerebral cortex.

To examine co-rippling at the mechanistic level, Ilya Verzhbinsky, an M.D./Ph.D. candidate in UC San Diego School of Medicine's Medical Scientist Training Program completing his research in Halgren's lab, led a [study](#) published in the *Proceedings of the National Academy of Sciences* that looked at what happens to single neurons firing in different cortical areas during ripples. The present study looks at the phenomenon with a wider lens, asking how the many billions of neurons in the cortex are able to coordinate this firing to process information.

"There are 16 billion neurons in the cortex—double the number of people on Earth," said Halgren. "In the same way, a large chorus needs to be organized to sound as a single entity, our brain neurons need to be coordinated to produce a single thought or action."

"Co-rippling is like neurons singing on pitch and in rhythm, allowing us to integrate information and make sense of the world. Unless they're co-rippling, these neurons have virtually no effect on the other, but once ripples are present about two thirds of neuron pairs in the cortex become synchronized. We were surprised by how powerful the effect was."

Co-rippling in the cortex has been difficult to observe in humans due to limitations of noninvasive brain scanning. To work around this problem, the researchers used an approach called intracranial electroencephalography (EEG) scanning, which measures the electrical activity of the brain from inside the skull.

The team studied a group of 13 patients with drug-resistant epilepsy who were already undergoing EEG monitoring as part of their care. This provided an opportunity to study the activity of the brain in more depth than typical brain scans using noninvasive approaches.

Participants were shown a series of animal names interspersed with strings of random consonants or nonsense fonts and then asked to press a button to indicate the animal whose name they saw.

The researchers observed three stages of cognition during these tests: an initial hierarchical phase in visual areas of the cortex in which the participant could see the word without conscious understanding of it; a second stage in which this information was "seeded" with co-ripples into other areas of the cortex involved in more complex cognitive functions; and a final phase, again with co-ripples, where the information across the cortex is integrated into conscious knowledge and a behavioral response—pressing the button.

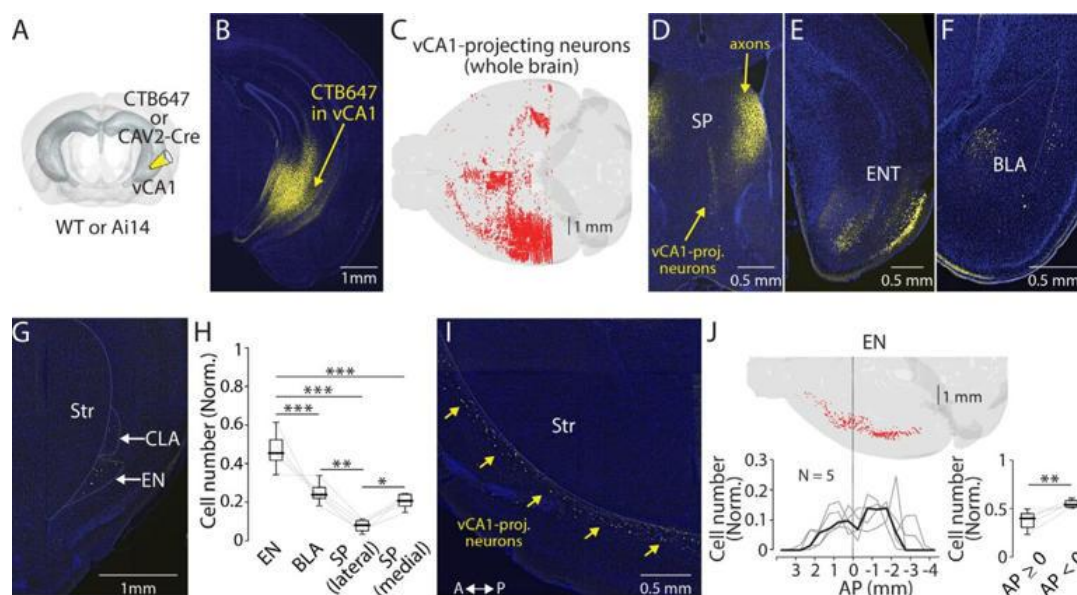
The researchers found that throughout the exercise, co-rippling occurred between the various parts of the brain engaged in these cognitive stages, but the rippling was stronger when the participants were reading real words.

The study's findings have potential long-term implications for the treatment of neurological and psychiatric disorders, such as schizophrenia, which are characterized by disruptions in these information integration processes.

"It will be easier to find ways to reintegrate the mind in people with these disorders if we can better understand how minds are integrated in typical, healthy cases," added Halgren.

More broadly, the study's findings have significant implications for our understanding of the link between brain function and human experience.

"This is a fundamental question of human existence and gets at the heart of the relationship between mind and brain," said Halgren. "By understanding how our brain's neurons work together, we can gain new insights into the nature of consciousness itself."



Endopiriform projects to the ventral CA1. Credit: eLife (2024). DOI: 10.7554/eLife.99642.1

Daily, we encounter new people, situations, and things that require our attention. Fortunately, there is an area in the brain that contributes to consciousness and awareness. This area is called the "Claustrum complex" and is located deep within the brain in each hemisphere.

Today, we know that many diseases related to higher cognitive function, such as Alzheimer's, schizophrenia, and ADD/ADHD, are closely linked to abnormal function of this particular part of the brain. However, we still do not fully understand how the different parts of the claustrum complex work or how its circuits and communication system are organized.

Researchers at Aarhus University have now uncovered this, and their results identify, down to the cellular level, which part of the claustrum complex controls our ability to discriminate familiar and novel things.

"Our study focuses on an area of the claustrum called the 'endopiriform,' which is a relatively unknown brain structure despite its unique brain network and cellular properties," explains Asami Tanimura, an associate professor and the lead researcher.

"For the first time, we have dissected the circuit of endopiriform to the hippocampus, and demonstrated how this pathway is crucial for recognition memory."

Using experiments on mice, researchers were able to observe how the mice's behavior changed when they respectively "turned on" and "turned off" the activity in this specific cell group.

Asami explains, "We observed that the cells in the endopiriform were active when the mice interacted with new conspecifics or objects, and when we inhibited this cell group, it reduced the mice's ability to distinguish novel mouse or object from familiar ones."

Based on this, the researchers concluded that this specific cell group in the claustrum seems to play a key role in sending memory-guided attention signal to the hippocampus.

"This is entirely new knowledge about this small but important part of the brain, and it gives us a unique understanding of the special circuit involved in recognition memory," explains Asami.

What this knowledge might mean, and whether it could lead to the development of new treatment methods targeted at disorders in this part of the brain, remains to be seen. However, Asami and her colleagues are optimistic, "To develop effective treatment methods, a very detailed understanding of the cells' circuits is required. With our study, we have at least opened a door that has previously been closed in terms of specific role of the endopiriform-hippocampal circuit on higher cognitive function."

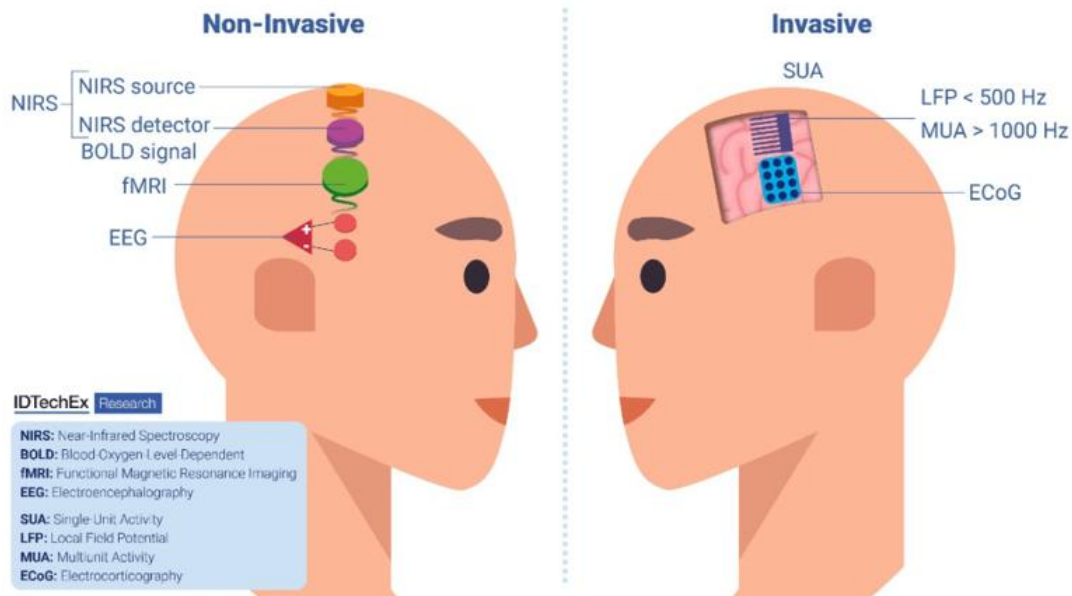


Brain computer interfaces represents an array of technologies that can decode neural signals, writes DR TESS SKYRME, senior technology analyst at IDTechEx.

The brain computer interface market represents an array of technologies which can decode neural signals, or in other words, read minds.

Electrodes or sensors can be placed either on the surface of the head, within the skull, or even within the brain itself to record brain activity. This data can then be used for cursor and keyboard control, speech decoding, and even exo-skeletons.

This technology has the potential to revolutionise the quality of life for people living with spinal cord injury, quadriplegia, and other motor and speech function impairments. IDTechEx predicts in their latest report, [*Brain Computer Interfaces 2025-2045: Technologies, Players, Forecasts*](#), that there will be evolving opportunities for both non-invasive and invasive technologies across the next twenty years, with the overall brain computer interface market forecasted to grow to over US\$1.6-billion by 2045.



Market for mind-reading takes shape

An overview of the major non-invasive and invasive methods of brain-computer interfacing. Source: IDTechEx

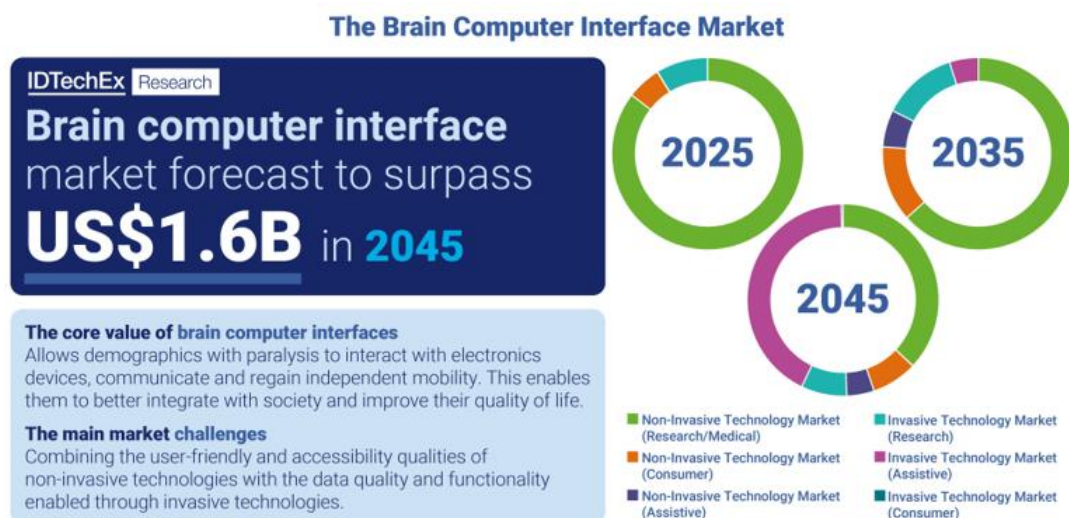
Non-invasive technology – the next generation of consumer HMI?

Non-invasive technology approaches include electroencephalography (EEG), functional near infrared spectroscopy (fNIRS), and now even wearable magnetoencephalography (MEG). While non-invasive devices have an established market for brain monitoring, their potential for brain computer interfacing is yet to be fully realized. However, as the technology continues to improve, so do data processing techniques. This is complemented by an increased consumer acceptance of head-worn [wearables](#) such as hearables and [AR/VR headsets](#).

IDTechEx expects the scale of market opportunity will largely be dictated by the success of other human machine interfacing (HMI) approaches emerging for the next generation of consumer devices. This includes competition from approaches such as electromyography (EMG), eye tracking, and hand tracking. Yet, with more and more demonstrations of non-invasive BCIs being used for 'mind-controlled' gaming, wheelchair control, and speech decoding, this sector is putting pressure on the less accessible invasive sector to perform.

Invasive technology – big names, big promises, big challenges

The hype around invasive brain computer interfaces remains high. High-profile companies such as Neuralink and Blackrock Neurotech have gained more public attention as trials in human patients begin and funding levels dramatically increase. Yet more players are seeking to enter this market than many realize, competing on levels of invasiveness, biocompatibility, system complexity, and time to market. Collectively, this eco-system is making big promises about the revolutionary potential of their technology in becoming assistive tools that can rapidly improve patient quality of life. Yet behind the headlines, there are big challenges ahead for this sector, and the pressure to demonstrate the rewards outweighing the risks is mounting.

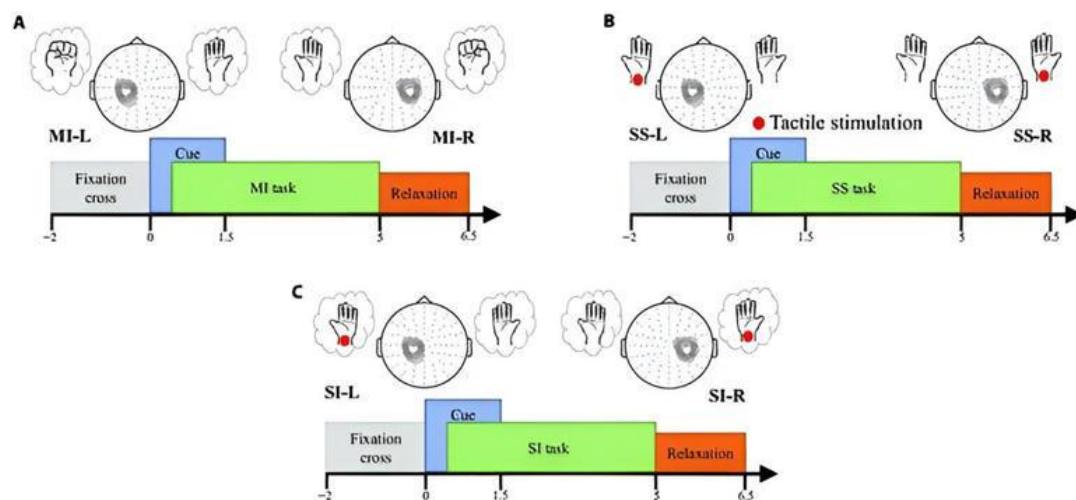


Market for mind-reading takes shape

The brain computer interface market. Source: IDTechEx

Market outlook

IDTechEx's latest report, "[Brain Computer Interfaces 2025-2045: Technologies, Players, Forecasts](#)", analyses the major technologies, players, applications, and challenges within the market. It includes coverage across non-invasive and invasive technologies, comparisons across key technical benchmarks, and market forecasts from 2025 to 2045. There is also detailed coverage of supply chain innovations impacting this market, including coverage of [wearable sensors](#) such as dry-electrodes, photo-detectors, and magnetic field sensors, including [quantum sensors](#).



Researchers from Zhejiang University have unveiled significant findings that could enhance brain-computer interface (BCI) technologies, marking a crucial step towards more intuitive neuroprosthetic control and advanced rehabilitation therapies. Credit: Huan Wen, The Department of Neurobiology, Affiliated Mental Health Center & Hangzhou Seventh People's Hospital, Zhejiang University School of Medicine.

In a study recently published in the journal *Cyborg and Bionic Systems*,

researchers from Zhejiang University have unveiled significant findings that could enhance brain-computer interface (BCI) technologies, marking a crucial step towards more intuitive neuroprosthetic control and advanced rehabilitation therapies.

The study, titled "[Neural Correlates of Motor/Tactile Imagery and Tactile Sensation in a BCI paradigm: A High-Density EEG Source Imaging Study](#)," employed high-density electroencephalogram (EEG) recordings to delve into the neural dynamics of motor and tactile imagery.

Brain-computer interfaces, devices that translate brain activity into commands for external software or hardware, have predominantly utilized motor imagery tasks where subjects imagine moving parts of their body without actual motion. This study expands on the BCI concept by integrating sensory imagery tasks, particularly focusing on tactile sensations, thereby providing new avenues for BCI applications.

The research team, led by Huan Wen and Lin Yao, conducted experiments involving eleven participants who were instructed to engage in both motor imagery (MI) and sensory imagery (SI) tasks. These tasks were designed to evoke brain responses from imagining motor actions and tactile sensations without physical stimuli. Using sophisticated EEG source imaging techniques, the study systematically examined the cortical activation differences and correlations between these tasks.

Key findings revealed that imagined tactile and motor tasks activate distinct regions within the sensorimotor cortex. While both tasks showed similar patterns in alpha bands, critical differences were noted in other frequency bands, indicating unique underlying neurophysiological processes. For instance, real sensory stimulation (SS) and imagined sensory tasks exhibited comparable activation patterns, suggesting potential strategies for training BCI systems.

This study is the first of its kind to use high-density EEG recordings to explore the intricate relationship between motor and tactile imagery. The researchers' approach has allowed for a detailed examination of the cortical sources of EEG signals, providing insights that were previously unattainable with traditional EEG methods.

The implications of these findings are vast. For one, they could significantly improve the accuracy and efficiency of BCIs, particularly in distinguishing between different types of imagery, which is crucial for the precise control of neuroprosthetics.

Moreover, the study paves the way for the development of new BCI designs that could include more diverse and complex commands, enhancing the interface's functionality.

In rehabilitation, these findings could revolutionize treatment protocols. Patients recovering from strokes or other motor impairments could benefit from tailored BCI therapies that harness both motor and tactile imagery, potentially accelerating the recovery process and improving outcomes.

The research also highlights the importance of sensory imagery in BCIs, an area that has received less attention compared to motor imagery. By demonstrating the feasibility and effectiveness of including sensory tasks in BCI frameworks, the

study invites further exploration into multi-modal BCIs that could support more natural interactions with technology.

As we advance towards more integrated and responsive BCIs, the work of Wen, Yao, and their team provides a critical foundation for future innovations. Their study not only expands our understanding of the brain's imaging capabilities but also opens new pathways for enhancing human-computer interaction.

Elon Musk has long touted the potential for brain computer-interfaces (BCIs) to give humans the ability to control machines with our minds. But communication is a two-way street. What happens when the computers stop receiving commands and start sending them?

A group of researchers in China recently developed a machine interface that allowed them to manipulate what a subject could or couldn't see. The purpose of the study was to investigate interventions for people with partial or complete loss of sight.

In order to test their hypothesis, the researchers [conducted](#) experiments on sedated cats and measured their brain activity as they experienced specific forms of external stimulation.

Per the team's research paper:

"This demonstration supports the possibility that externally applied focal stimulation can access functional circuitry known to underlie normal visual perception."

Visual prosthetics

Basically, the researchers showed that it's technically possible for a system connected to a brain computer-interface to activate the same "circuits" in our eyes and brains that engage when we see something.

While this research focused specifically on cats, previous research has shown similar techniques were able to produce vague images of numbers and other simple pictures in the minds of humans without sight.

The team in China introduced several novel techniques in their paper. Perhaps the most important of which is what essentially amounts to the ability to interface with the visual cortex at the “columnar level.”

This could lead to prosthetics that allow BCIs to remove, insert, or modify visual information, even in some people who are completely blind.

What could go wrong?

BCIs tend to have both “read” and “write” functions. If we imagine the brain and nervous system as a computer, and the BCI as a networking device meant to connect it to another computer, then both computers could technically have the same administrative privileges.

This means that, [as Elon Musk’s Neuralink has demonstrated](#), a human with a BCI can control computer functions with their thoughts. It also means that, theoretically, a computer can send commands back.

The Chinese research team discusses several theoretical situations where a BCI capable of interacting with the eye-brain loop could have a major impact. While the study focused solely on the positive use cases, it’s not difficult to extrapolate the potential for harm from the team’s assertions.

Firstly, such a device could be used to influence a person’s behavior. While this could have myriad benefits for people with conditions such as nystagmus — an affliction causing uncontrollable eye movements — there also exists the possibility for nefarious use.

One dystopian view would involve a mechanism that forces us to pay attention to content. In this scenario, advertisements wouldn’t just take up space on your screen, you’d literally be forced to focus your visual perception on the ad.

In another, darker scenario, a bad actor with sufficient access (whether human or AI) could send a signal to a victim’s BCI causing them to experience vertigo, loss of balance, or nausea-inducing visual patterns.

The device could also be used to alter information in real time, potentially blurring faces or making the numbers in a transaction appear different. And, while it could also be used to restore vision in a blind person, it could also be used to force someone to hallucinate completely false images.

While it's clear the scientists in China and at other laboratories working on BCIs, such as Musk's Neuralink, are developing technology to assist people, the idea of introducing these devices to the general public as "enhancement" is, potentially, fraught with risk.

A remote, 'long-range' and 'large-volume' mind control device has been unveiled in [South Korea](#) — with plans to use the tech for 'non-invasive' medical procedures.

Researchers with Korea's Institute for Basic Science (IBS) developed the hardware, which manipulates the brain from a distance using magnetic fields, and tested the tech by inducing 'maternal' instincts in their female test subjects: mice.

In another test, they exposed a test group of lab mice to magnetic fields designed to reduce appetite, leading to a 10-percent loss in body-weight, or about 4.3 grams.

'This is the world's first technology to freely control specific brain regions using magnetic fields,' according to the professor of chemistry and nanomedicine who helped spearhead the new effort.



© Alamy Stock Photo

A remote mind control device has been unveiled in South Korea - with plans to use the tech for 'non-invasive' medical procedures. In one test, researchers exposed lab mice to magnetic fields designed to reduce appetite, leading to a 10-percent loss in body-weight (4.3 grams)© Provided by Daily Mail

That researcher, Dr Cheon Jinwoo, director of South Korea's IBS Center for Nanomedicine said he expects the new hardware to be used for a variety of healthcare applications where he said it was sorely needed.

'We expect it to be widely used in research to understand brain functions, sophisticated artificial neural networks, two-way brain-computer interface technologies, and new treatments for neurological disorders,' Dr Cheon said.

But despite the science fiction quality of remote mind control, health experts noted that magnetic fields have been used successfully in medical imaging for decades.

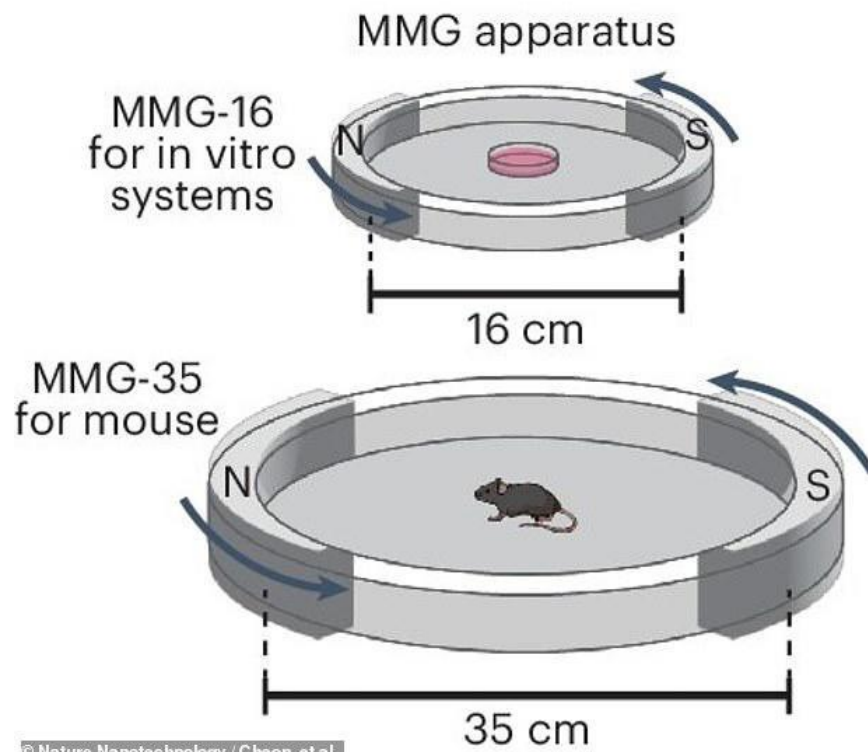
'The concept of using magnetic fields to manipulate biological systems is now well established,' [Dr Felix Leroy](#), a senior scientist at Spain's Instituto de Neurociencias, wrote in an op-ed that accompanied the new study in [Nature Nanotechnology](#).

'It has been applied in various fields,' he noted, 'magnetic resonance imaging [MRI], transcranial magnetic stimulation, and magnetic hyperthermia for cancer treatment.'

The novelty added by South Korea's IBS team was the genetic fabrication of specialized nanomaterials, whose role within neurons in the brain could be tuned from afar via carefully selected magnetic fields.

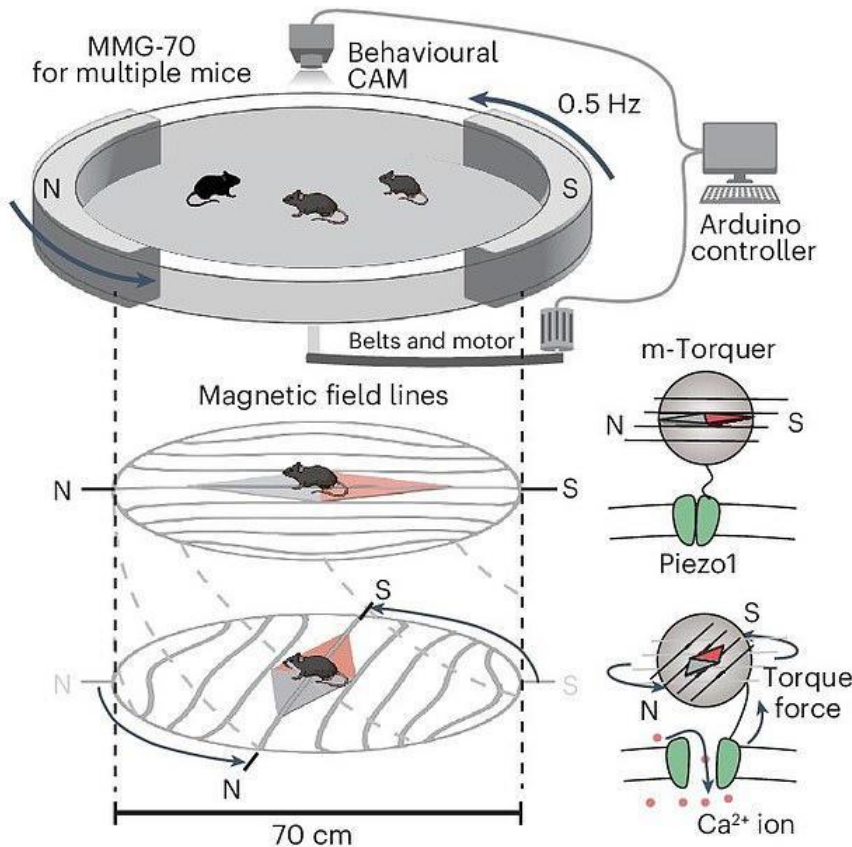
The technique, formally called magneto-mechanical genetics (MMG), guided Dr Cheon and his colleagues as they developed their brain-modulating technology.

In the new study, published this July in Nature Nanotechnology, the team called their invention Nano-MIND, for '[Nano-Magnetogenetic Interface for NeuroDynamics](#).'



© Nature Nanotechnology / Cheon, et al

Dr Cheon Jinwoo, director of South Korea's IBS Center for Nanomedicine, said he expects the new hardware to be used for a variety of healthcare applications where it is sorely needed. Above a diagram of the magnetic device in which the study's lab mice were remote controlled© Provided by Daily Mail



© Nature Nanotechnology / Cheon, et al

In the group's test of maternal instincts, the magnetic stimulation of certain female lab rats encouraged them to locate and collect their lost rat 'pups' more quickly in a maze-like course. The stimulated female rats began approaching the pups faster - on average 16 seconds faster© Provided by Daily Mail

The scientists' designed special mice for their experiments using a gene-replacement technique known to researchers as Cre-Lox recombination.

These genetically engineered lab mice developed more magnetically sensitive 'ion channels' which act as gates in their neurons, or nervous system cells, allowing certain molecules and atoms to enter at certain times and certain rates.

In the group's test of maternal instincts, the MMG stimulation of certain female lab rats encouraged them to locate and collect their lost rat 'pups' more quickly in a maze-like course.

The female rats stimulated by Nano-MIND began approaching the pups faster — on average 16 seconds faster — and 'quickly retrieved all the three pups in all the trials,' the researchers wrote.

The team also conducted a two-week experiment with control group and experimental group mice on how these genetically engineered animals would react to Nano-MIND magnetic impulses encouraging them to eat more or eat less.

The technology proved capable of encouraging the mice both to overeat and to undereat.

In the experiment in which the MMG signal was encouraged the mice to eat, their body weight increased by approximately 7.5 grams on average, meaning roughly an 18-percent gain in body-weight.

The fasting magnetic impulse led to mice losing less (10-percent loss in body weight or about 4.3 grams), but significantly did not slow down the mice or inhibit their ability to move.

'Reduced feeding did not affect locomotion,' they wrote, implying that the effect was purely on appetite and not otherwise handicapping the mice's ability to operate.

The technology, Dr Cheon and his team wrote, will find its most immediate use in helping health researchers understand which parts of the brain and the rest of the neurological system are responsible for which moods and other behaviors.

But in his opinion piece on the Nano-MIND innovation and its gene-replacement aspect, Dr Leroy in Spain cautioned against rushing too soon to human testing.

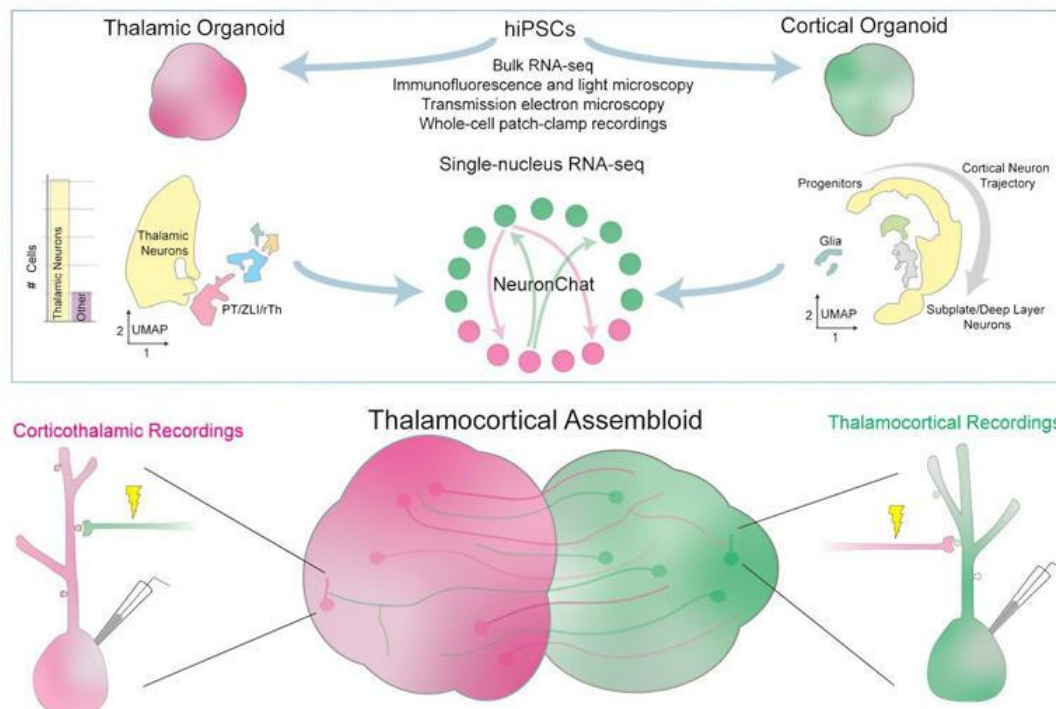
'Further studies are needed to assess potential cumulative effects, including neuroadaptation or neurotoxicity,' Dr Leroy advised.

The ability to study human neurological systems depends on having viable, accurate models of brain function. St. Jude researchers have now created a model for such research by combining thalamic cells and cortical cells derived from human induced pluripotent stem cells.

The thalamocortical system mediates multiple sensory and cognitive processes, such as perception, learning and memory. The researchers developed a model of

a primitive human thalamocortical system by maintaining thalamic and cortical cell masses known as organoids in close proximity in a culture dish.

In this model, the neurons in both organoids develop and grow long-ranging processes (axons) that extend to the opposite organoid and form functional connections (synapses). The researchers determined that when these synapses are stimulated, they undergo long-term strengthening and weakening of their electrical signals, which is the hallmark of synaptic plasticity, a process that underlies certain forms of learning and memory.



Credit: Cell Reports (2024). DOI: 10.1016/j.celrep.2024.114503© Provided by Medical Xpress

The new human model was successfully validated against established animal models, demonstrating species differences in underlying mechanisms and emphasizing the importance of accurate human models. These findings were [published](#) this week in *Cell Reports*.

To study neuronal function in human models, scientists have historically relied on low-resolution methods that measure responses from a group of neurons, because high-resolution methods that measure single-cell or synaptic responses in humans were not available. St. Jude researchers wanted to address this.

"Our goal is to not only study neural circuits but also truly understand communication between neurons in the human brain," said corresponding author

Stanislav Zakharenko, MD, Ph.D., St. Jude Department of Developmental Neurobiology. "Therefore, we need to measure the activity between individual neurons at the sub-micron synaptic level."

Studying synapses at the sub-micron level

Synaptic plasticity is based on the long-term strengthening and weakening of synapses as our brains develop and encode new information, but the minute scale at which this takes place means studying synapses in humans has been a long-standing dilemma in the field.

To address this, the researchers leveraged the recent surge in brain organoid research. "The technology has reached such a level where we can grow specific neurons, such as cortical or thalamic cells," explained Zakharenko. "Once the cells are grown, they self-organize into a mass called an organoid and start to develop long-range processes (axons) with pre- and post-synaptic specializations."

Researchers figured out that if two different types of organoids fuse together, they create an "assembloid" in which the two types of neurons continue to develop, send processes toward each other, and then begin to communicate.

However, for the researchers, that was only the first step. "We clumped thalamic and cortical cells together, and they began to self-organize and make connections," Zakharenko explained. "But this could have just been a random, disorganized process. We needed to see if they could exhibit the synaptic plasticity characteristics of thalamocortical and corticothalamic synapses."

Building an accurate model

A major hurdle in the organoid field has been selectivity. There are many types of neurons that communicate differently depending on the neurotransmitters they produce. The researchers utilized a cell culture system to select almost exclusively (>80%) neurons that communicate via the release of the neurotransmitter glutamate. This enabled the researchers to reliably measure synaptic plasticity using single-cell electrophysiological tools and high-resolution imaging.

Long-term strengthening and weakening of neuronal connections are traits of plasticity; as new bridges are formed, old ones need to be torn down. By monitoring the transmission of glutamate signaling, the researchers confirmed that the two different neurons were mirroring the behavior of the thalamocortical system in the human brain and, importantly, re-contextualizing what had been modeled before.

"We found that we could apply the same patterns of stimulation as have been applied to other animal models and the assembloids did the same thing, but with a slightly different mechanism," Zakharenko emphasized.

While no single model system can tell a complete story, the addition of such organoids and assembloids to the neurological research toolkit is a boon for the field. The thalamocortical assembloid model, for example, carries huge potential in the study of neurological or psychiatric disorders.

"We know that thalamocortical deficits occur in schizophrenia, autism, and other psychiatric disorders, so in theory, we can extract cells from a patient or introduce a disease-causing mutation to healthy human cells and generate an assembloid model of a particular disease," Zakharenko said. "With this model, we can then study synaptic plasticity as a consequence of the known mutation."



Credit: Pixabay© Provided by Tech Xplore

Researchers from the MRC Brain Network Dynamics Unit and Oxford

University's Department of Computer Science have set out a new principle to explain how the brain adjusts connections between neurons during learning. This new insight may guide further research on learning in brain networks and may inspire faster and more robust learning algorithms in artificial intelligence.

The essence of learning is to pinpoint which components in the information-processing pipeline are responsible for an error in output. In artificial intelligence, this is achieved by backpropagation: adjusting a model's parameters to reduce the error in the output. Many researchers believe that the brain employs a similar learning principle.

However, the biological brain is superior to current machine learning systems. For example, we can learn new information by just seeing it once, while artificial systems need to be trained hundreds of times with the same pieces of information to learn them. Furthermore, we can learn new information while maintaining the knowledge we already have, while learning new information in artificial neural networks often interferes with existing knowledge and degrades it rapidly.

These observations motivated the researchers to identify the fundamental principle employed by the brain during learning. They looked at some existing sets of mathematical equations describing changes in the behavior of neurons and in the synaptic connections between them. They analyzed and simulated these information-processing models and found that they employ a fundamentally different learning principle from that used by artificial neural networks.

In artificial neural networks, an external algorithm tries to modify synaptic connections in order to reduce error, whereas the researchers propose that the human brain first settles the activity of neurons into an optimal balanced configuration before adjusting synaptic connections. The researchers posit that this is in fact an efficient feature of the way that human brains learn. This is because it reduces interference by preserving existing knowledge, which in turn speeds up learning.

Writing in *Nature Neuroscience*, the researchers describe this new learning principle, which they have termed "prospective configuration." They demonstrated in computer simulations that models employing this prospective configuration can learn faster and more effectively than artificial neural networks in tasks that are typically faced by animals and humans in nature.

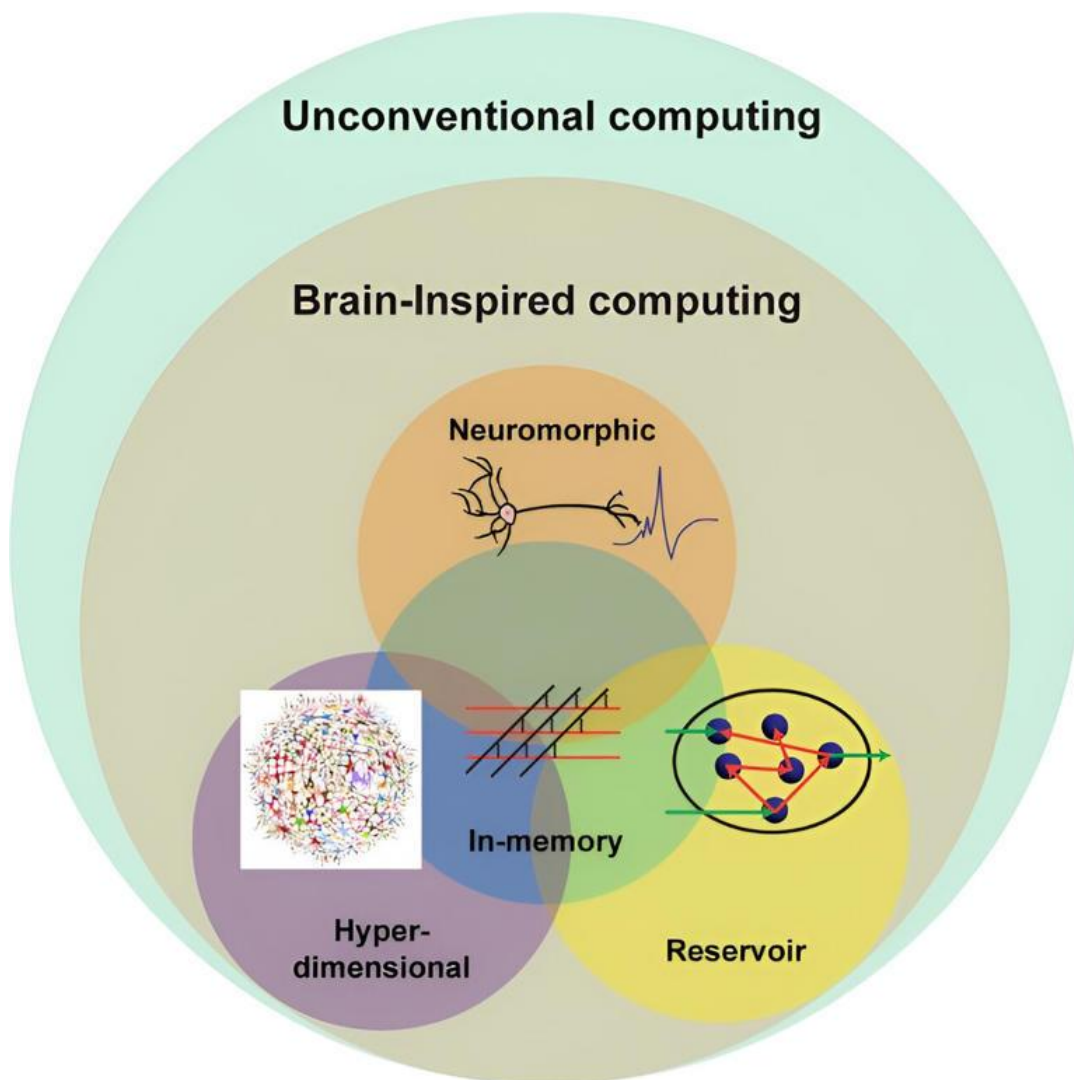
The authors use the real-life example of a bear fishing for salmon. The bear can see the river and it has learned that if it can also hear the river and smell the salmon it is likely to catch one. But one day, the bear arrives at the river with a damaged ear, so it can't hear it.

In an artificial neural network information processing model, this lack of hearing would also result in a lack of smell (because while learning there is no sound, backpropagation would change multiple connections including those between neurons encoding the river and the salmon) and the bear would conclude that there is no salmon, and go hungry. But in the animal brain, the lack of sound does not interfere with the knowledge that there is still the smell of the salmon, therefore the salmon is still likely to be there for catching.

The researchers developed a mathematical theory showing that letting neurons settle into a prospective configuration reduces interference between information during learning. They demonstrated that prospective configuration explains neural activity and behavior in multiple learning experiments better than artificial neural networks.

Lead researcher Professor Rafal Bogacz of MRC Brain Network Dynamics Unit and Oxford's Nuffield Department of Clinical Neurosciences says, "There is currently a big gap between abstract models performing prospective configuration, and our detailed knowledge of anatomy of brain networks. Future research by our group aims to bridge the gap between abstract models and real brains, and understand how the algorithm of prospective configuration is implemented in anatomically identified cortical networks."

The first author of the study Dr. Yuhang Song adds, "In the case of machine learning, the simulation of prospective configuration on existing computers is slow, because they operate in fundamentally different ways from the biological brain. A new type of computer or dedicated brain-inspired hardware needs to be developed, that will be able to implement prospective configuration rapidly and with little energy use."



Credit: The European Physical Journal B (2024). DOI: 10.1140/epjb/s10051-024-00703-6

The recent widespread and long-lasting chaos caused by Microsoft outages across the globe exemplifies just how integral computing has become to our lives. Yet, as computer hardware and software improve, arguably the most sophisticated and powerful computer we know of is still the human brain.

Sharing its computing power through billions of neurons interacting via trillions of synapses, the human brain doesn't just compete with the most powerful

supercomputers devised, but by consuming less energy than it takes to power the light in your fridge, your brain beats computers in the efficiency department, hands down.

It is little wonder that scientists and computer engineers are inspired by the human brain when it comes to devising new computing methods.

In a new paper [published](#) in *The European Physical Journal B*, Mohamadreza Zolfagharinejad from the University of Twente and his co-authors discuss the rise of brain-inspired computing, its burgeoning demand, and its importance in the modern world. The review offers a comprehensive overview of the latest advances in brain-inspired computing hardware.

"Brain-inspired computing is a growing and interdisciplinary area of research that investigates how the computational principles of the biological brain can be translated into hardware design to achieve improved energy efficiency," the authors write. "However, the vast scope of the field has made it challenging to compare and assess the effectiveness of the solutions compared to state-of-the-art digital counterparts."

This prior difficulty has been at least partially due to the fact that brain-inspired computing encompasses a swathe of subfields, including neuromorphic and in-memory computing. To perform their review, the team highlighted various studies and potential applications that could greatly benefit from brain-inspired computing systems and compared their reported computational accuracy. They ensured a fair comparison of the performance of different approaches by applying a standardized normalization approach for energy efficiency reports.

The authors did not neglect to remember the human aspects of the brain when it comes to assessing literature, ensuring their comprehensive overview was accessible for researchers from diverse backgrounds by introducing key concepts and pointing out respective in-depth topical reviews.

"With the rising demand for more powerful yet energy-efficient hardware for large-scale artificial neural networks, brain-inspired computing is emerging as a promising solution for enabling energy-efficient computing and expanding AI to the edge," the authors write.

Surprisingly, one study shows that even two minutes of this type of activity provides clear cognitive benefits.

In the same way that [more than 80 percent of people surveyed](#) think they are above-average drivers, and fewer than 1 percent consider themselves "worse than average" (each a mathematical impossibility), I like to think I'm smart. Not extremely smart. Not super smart. Just smart.

And I would definitely like to [be smarter](#).

Fortunately, it's possible to improve your ability to learn, retain, and use what you learn. But that takes a lot of work.

Or not.

If you want to increase your [learning speed](#), make [smarter decisions](#), and increase your overall [level of intelligence](#), a [study published](#) in the *Journal of Epidemiology and Community Health* found that just six to 10 minutes of moderate to vigorous exercise can improve your working memory and significantly improve higher-level cognitive skills like organization, prioritization, and planning.

If you're wondering, "moderate exertion" involves things like fast walking. Slow jogging. Climbing stairs. Think any activity that, while not easy, will still allow you to carry on a conversation. "Vigorous exertion" is just what it sounds like: cycling, swimming, HIIT workouts, fast jogging, etc.

On the flip side, *not* getting a little exercise can have a negative impact on your mental abilities. The study found that cognition declined by 1 to 2 percent -- not a lot, granted, but still -- when eight minutes of moderate to vigorous physical activity was replaced by sitting.

As the [researchers write](#):

Relative to time spent in other behaviors, greater MVPA (moderate to vigorous physical activity) was associated with higher cognitive scores. Loss of MVPA time, given its smaller relative amount, appears most deleterious.

Efforts should be made to preserve MVPA time, or reinforce it in place of other behaviors.

Yep: if you want to get smarter, get moving for at least six minutes a day.

Or more, if you like. The study found that the more time you spend exercising -- obviously up to a point -- the greater the mental benefits. (And, of course, the physical benefits.)

Other research agrees. For one thing, exercise can slow or even reverse the physical decay of your brain. Contrary to conventional wisdom, new brain cells can be created: Research shows [exercise can increase the size of your hippocampus](#), even in your 60s and 70s, mitigating the impact of age-related memory loss. (Having witnessed what dementia did to my father, that's one of the many reasons I spend about an hour exercising at least five times a week.)

Then again, if six to 10 minutes sounds like too much, a [meta-review of a number of studies published](#) in *Transitional Sports Medicine* found that even "aerobic exercise for two minutes at moderate-to-high intensity improved attention, concentration, and learning and memory functions for up to two hours."

If you want a longer-term boost -- who doesn't? -- a [study published](#) in the *Proceedings of the National Academy of Sciences* found that participants who walked briskly -- shooting for a target heart rate of 60 to 75 percent of max -- for 40 minutes, three times a week, increased hippocampal volume by slightly over 2 percent.

I know. That's a lot of research. Sum it all up, and a few minutes of exercise will help improve learning and memory. A few more minutes will improve your planning and organizational skills. Movement makes you smarter.

And healthier.

What does "moderate exertion" look like in real life? The goal is to get your heart rate to somewhere between 60 and 75 percent of max. Generally speaking, max heart rate is 220 beats per minute minus your age. If you're in your 60s (hi, me!), your max heart rate is somewhere around 160 beats per minute; 60 percent of that means "moderate exertion" raises it to approximately 100 beats per minute.

At that rate, I can carry on a conversation while only occasionally having to pause to take a deep breath or two. That's the goal: increased heart rate, without undue strain.

Any form of exercise -- jogging, easy spin on an exercise bike, bodyweight training, etc. -- that gets me there works.

And that's the key. Pick an activity or activities you like to do. Consistency, in this and nearly everything else, is the key. Pick one thing you'll be willing, if not happy, to do every day.

The Fascinating Timeline of Brain Development

©Image Credit: Gorodenkoff/Shutterstock.

So, what does normal brain development look like? It's a complex process that starts before we're even born:

- By 35 days after conception, the early structures of the brain and spinal cord are forming, and the first neurons are produced.
- Around 100 days after conception, neurons are born deep in the brain at an astonishing rate of about 15 million per hour. They then migrate to their final positions, guided by molecular signals.
- At birth, the brain is only about 25% the size of an adult brain. Then a period of rapid growth begins – by age 2, the brain reaches 80% of its adult size as neuron circuitry matures and protective glial cells are born.
- The brain reaches its full size around age 14, but the circuitry continues to rewire until early adulthood, around age 25.

Experience plays a key role in shaping the brain's development throughout this process. The connections between neurons are strengthened or pruned based on the input they receive. This neuroplasticity allows the brain to adapt and learn from its environment.^(ref)

Rethinking Brain Aging & Disorders

©ktsdesign/Deposit Photos.

These new insights into brain development have major implications for how we understand brain aging and disorders. Functional brain connectivity, the way different regions of the brain interact, undergoes complex changes across the lifespan:

- In early childhood, brain networks start to segregate and become more specialized.
- From adolescence to early adulthood, brain networks become more integrated.

- In middle age, this shifts and brain networks start to become less segregated and reorganize on a large scale.
- In older age, brain regions become less functionally specialized, which is associated with cognitive decline.

Understanding these changes could help develop better-targeted treatments for brain disorders at different ages. For example, many psychoactive medications given to pregnant women and children have not been thoroughly tested for safety and long-term effects on the developing brain. More research in this area is critical.

There is also hope that interventions could slow or even reverse certain aspects of brain aging. Animal studies suggest that stem cells could potentially replenish declining neural stem cells.

Rare individuals over 80, known as “SuperAgers,” who have remarkable memory abilities, may hold clues to resisting age-related cognitive decline.

While the new findings on mice and monkeys are groundbreaking, the implications for humans are still a bit of a mystery. Humans develop complex skills like walking and talking much later than other mammals, so our brains may be on a totally different schedule.

Kasthuri suspects “something remarkable, something magical” is happening in human brain development compared to other species. Collaboration between neuroscientists and other experts will be key to unraveling these secrets and translating the findings into real-world applications.

What is clear is that the brain is an incredibly complex and ever-changing organ. From the womb to old age, our brains constantly develop, adapt, and transform in ways we are only beginning to understand.

As research continues to evolve, it will open up exciting new possibilities for optimizing brain health and treating neurological disorders across the lifespan. The more we learn about the intricacies of the brain, the better equipped we’ll be to unlock its full potential.

Brain-computer interface startups augmenting human body

By [Oliver Mitchell](#) | December 22, 2021
Listen to this article

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The ultimate purpose of robotics is to improve the human condition. Our bodies are vulnerable to damage and disrepair. In the [Stanford Encyclopedia of Philosophy](#), the entry on “care robots” highlights the societal benefits over countering dystopian fears:

“One reason why the issue of care has come to the fore is that people have argued that we will need robots in aging societies. This argument makes problematic assumptions ... Most importantly, it ignores the nature of automation, which is not simply about replacing humans, but about allowing humans to work more efficiently. It is not very clear that there really is an issue here since the discussion mostly focuses on the fear of robots de-humanising care, but the actual and foreseeable robots in care are assistive robots for classic automation of technical tasks.”

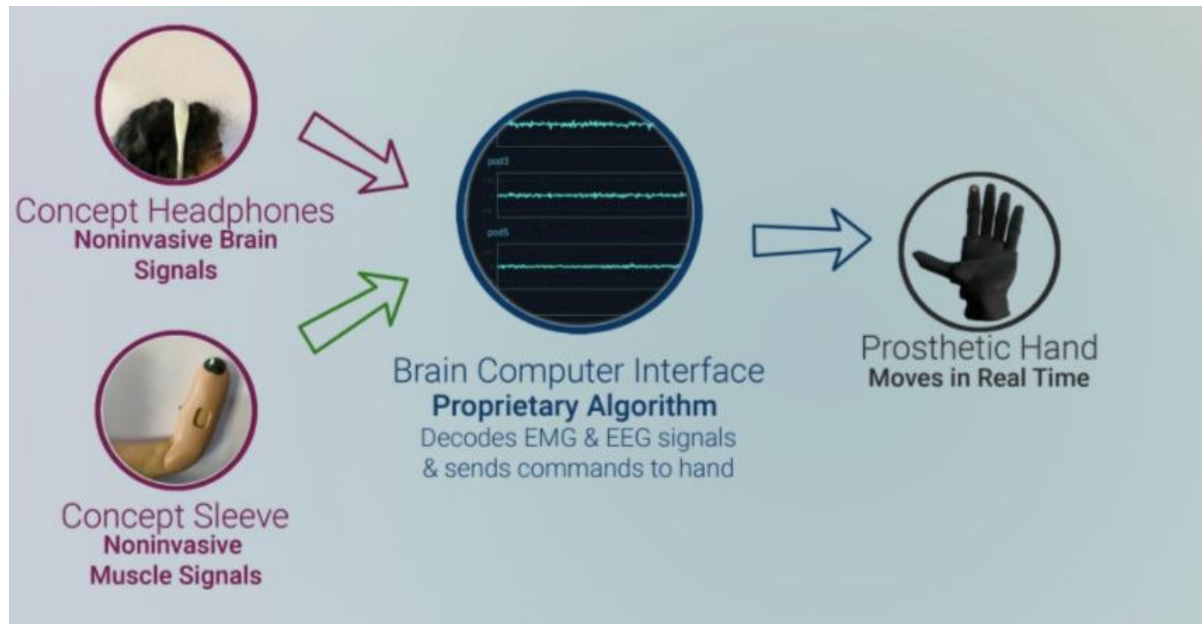
Understanding the nature of “care robots” is critical to furthering development and empowering more people with disabilities. This is the mission of ETH Zurich’s Cybathlon competition, which recently announced its third global, Olympic-style games for October 2024.

While the COVID-19 pandemic raged across the world in 2020, Cybathlon organizers persisted with their competition to use robots for medical rehabilitation. “We originally scheduled the event for May, and in March we realized we couldn’t do the event,” said Dr. Roland Sigrüst, the show’s organizer. “We had three years in preparation, so we had to cancel the event in Zurich in the arena. So we decided we can’t stop the movement, we needed to give the teams the platform to show the world what they have achieved. So we decided to make a global edition, which was decentralized with teams setting up race tracks in their home locations.”

Cybathlon 2020 evolved into a livestream event. He said Cybathlon 2024 will be a hybrid event with both remote teams and live participants jostling for bot glory in Zurich. Some past Cybathlon standouts include Scewo, a Swiss-based commercial stair climbing

wheelchair company, and Imperial College's Neuromechanics Rehab and Technology lab's robotic prosthesis. The contest has been gaining in popularity with 66 teams registered in 2016, 100 teams in 2020, and quite possibly 250 in 2024.

"We think the new approach is even more inclusive," boasted Sigrist. He said **Cyathlon 2024** will add two disciplines to address the needs of the visually impaired and severe upper and lower limb disabilities.



Brain-computer interface

One of the most promising control methodologies for roboticists aiming to develop medical therapies for quadriplegics and paraplegics is the brain-computer interface (BCI). This technology creates a communication pathway from the brain's electrical activity to an external device, such as a robotic arm or computer. Dr. Jacques Vidal at UCLA first published his seminal work on BCI in 1973, which subsequently led to many new discoveries around repairing cognitive and sensory-motor function.

Vini Tripathii is founder of **Invictus BCI**, a startup focused on developing a more functional prosthetic hand. She hopes to compete at the Cyathlon 2024 with her BCI-enabled prosthesis.

“Three years ago, a family member got very sick. It got so bad that doctors had to amputate her hand so that she could live. After the amputation, I thought that once she got a prosthetic, it would fix everything – but it didn’t,” she said. “In fact, even after getting a premium state-of-the-art prosthetic, she found herself struggling with even simple, mundane tasks. After speaking with other amputees and clinicians, I realized these were problems shared by millions of people, and that they were inherent in the prosthetic control system. I started researching alternative methods that could provide more intuitive and functional control.”

The BCI entrepreneur recently joined NYU Stern’s Endless Frontier Labs to begin the steps to commercialize her invention.

BCI market scope

The current BCI market is estimated to be close to \$2 billion and is estimated to double by 2026. The interest in mastering the cranium has lured the Department of Defense, IBM, and even Elon Musk in pushing the envelope of possibilities.

Musk’s startup, Neuralink, is building brain implants to directly connect cerebral cortexes to computers. Earlier this month at *The Wall Street Journal*’s CEO Summit, Musk bragged about his groundbreaking investment.

“Neuralink’s working well in monkeys, and we’re actually doing just a lot of testing and just confirming that it’s very safe and reliable, and the Neuralink device can be removed safely. We hope to have this in our first humans, which will be people that have severe spinal-cord injuries like tetraplegics, quadriplegics, next year, pending FDA approval.”

According *CB Insights*, other companies to watch in the space include Kernel, Dreem, Thync, Halo Neuroscience, Synchron, BrainCo, Neurable, Flow Neuroscience, Cognixion, Bitbrain Technologies, Paradromics, MELTIN MMI, Neuros Medical, NextMind, Emotiv, Q30 Innovations, BIOS, NeuroScouting, NeuroPace, and Leonardo DiCaprio’s MindMaze.

While the market for BCI is all-encompassing with recreational consumer products and psychological therapies, the greatest promise offers the ability of connecting robotic parts to compensate for human frailties.

"The problem lies not in the mechanics of the prosthetic hand, but the prosthetic control interface," said Tripathii. "Current prosthetic control systems are frustrating for amputees to use as they are unintuitive, capable of only a few grasps and have unreliable performance."

This personal journey led the Cornell scientist to BCI as the solution. "In essence, a BCI decodes neural activity and translates it into an external command: this can be used in a variety of applications, including assistive technology. The BCI decodes the received signals into a hand movement, then passes instructions for the prosthetic hand to perform that hand movement."

Cyathlon 2024

Tripathii's company is on the cusp of developing its first prototype complete with mechanical phalanges for a growing list of potential users. Tripathii hopes to showcase its proprietary robotic hand at Cyathlon 2024.

"Cyathlon is a unique opportunity to really test BCI performance in myriad day-to-day activities." She continued, "Most importantly, it is a forum where indomitable human spirit partners with human ingenuity to say that we can and we shall not be limited by any constraints. We are very excited to be joining in 2024."

This sentiment aligns well with the vision of Sigrist, who calls the conference "a movement." Tripathii professes that Cyathlon is really a catalyst for promoting technology like hers to ultimately change the paradigm of care.

"Many of the physical challenges that we currently face, whether from disabilities or old age, will become less of a challenge and more of an augmented task. BCI will transform the way we do things to make the world safer, more productive, and more accessible. It will make it possible to do work more dexterously, accelerate learning, and redefine how we create and interact with art, music and other media types."

ABOUT THE AUTHOR

Oliver Mitchell

Oliver Mitchell is a partner at ff Venture Capital. Oliver first joined ff VC in 2014 as a Limited Partner, and then in 2018 as a Venture Partner. Today, he takes a leading role on the investment team in expanding the portfolio's deep tech position with holdings in robotics, drones, artificial intelligence, and industrial automation technologies. Oliver also works with ffVC's investor relations in forging strategic relationships for our limited partners and corporate venture groups. In addition, he serves on the boards of Civ Robotics, Cambrian Intelligence, AppBind, Storyfit, and Cardflight.

Previously, Oliver ran his own investment portfolio of a dozen companies that have since returned 8 exits, including two IPOs (NVCR and EKSQ) and one unicorn (Triple Lift) with a combined value of over \$20 billion. Previous startup outcomes have included selling Holmes Protection to ADT/Tyco, AmeriCash to American Express, and launching RobotGalaxy, a national consumer S.T.E.M. brand. Oliver is an Adjunct Professor at Sy Syms School of Business, and frequent writer of trade periodicals.



Aerogel can obtain high hydrophobicity by simple chemical modifications. Credit: Thor Balkhed© Provided by Phys.org

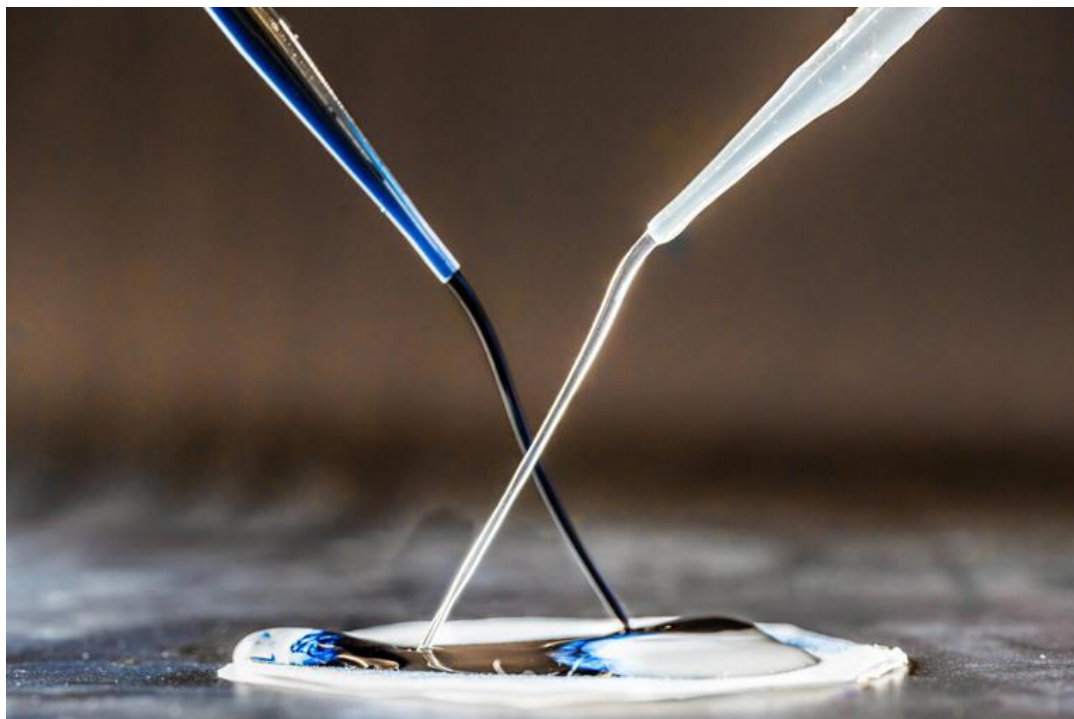
High-frequency terahertz waves have great potential for a number of applications including next-generation medical imaging and communication. Researchers at Linköping University, Sweden, have shown, in a study [published](#) in

the journal *Advanced Science*, that the transmission of terahertz light through an aerogel made of cellulose and a conducting polymer can be tuned. This is an important step to unlock more applications for terahertz waves.



Qilun Zhang and Chaoyang Kuang, researchers at the Laboratory of Organic Electronics. Credit: Thor Balkhed© Provided by Phys.org

The terahertz range covers wavelengths that lie between microwaves and infrared light on the electromagnetic spectrum. It has a very high frequency. Thanks to this, many researchers believe that the terahertz range has great potential for use in space exploration, security technology and communication systems, among other things.



The aerogels are fabricated using aqueous solutions and do not require complex fabrication procedures, thereby holding great promise for large-scale sustainable production at a low cost. Credit: Thor Balkhed© Provided by Phys.org

In medical imaging, it can also be an interesting substitute for X-ray examinations as the waves can pass through most non-conductive materials without damaging any tissue.

However, there are several technological barriers to overcome before terahertz signals can be widely used. For example, it is difficult to create terahertz radiation in an efficient way and materials that can receive and adjust the transmission of terahertz waves are needed.

Researchers at Linköping University have now developed a material whose absorption of terahertz signals can be turned on and off through a redox reaction. The material is an aerogel, which is one of the world's lightest solid materials.

"It's like an adjustable filter for terahertz light. In one state, the electromagnetic signal will not be absorbed and in the other state it can. That property can be useful for long-range signals from space or radar signals," says Shangzhi Chen, postdoc at the Laboratory of Organic Electronics, LOE, at Linköping University.

The Linköping researchers used a conducting polymer, PEDOT:PSS, and cellulose to create their aerogel. They also designed the aerogel with outdoor applications in mind. It is both water-repellent (hydrophobic) and can be naturally defrosted via heating by sunlight.

Conducting polymers have many advantages over other materials used to create tunable materials. Among other things, they are biocompatible, durable, and have a great ability to be tuned. The tunability comes from the ability to change the charge density in the material. The great advantages of cellulose are the relatively low production cost compared to other similar materials and that it is a renewable material which is key for sustainable applications.

"The transmission of terahertz waves in a broad frequency range could be regulated between around 13 % and 91 %, which is a very large modulation range," says Chaoyang Kuang, postdoc at LOE.

More information: Chaoyang Kuang et al, Switchable Broadband Terahertz Absorbers Based on Conducting Polymer-Cellulose Aerogels, *Advanced Science* (2023). [DOI:](#)

Picture this: In a world where smartphones are as ubiquitous as wristwatches, we're standing on the precipice of a monumental shift. The same devices that revolutionized how we communicate, work, and play are now hinting at their own obsolescence.

As we hold our sleek, feature-packed smartphones, we can't help but wonder: What could possibly come next? What new invention is lurking around the corner, ready to make these indispensable gadgets a relic of the past?



Image Credit: Daisy Daisy/Shutterstock.© Provided by Viral Chatter

The answer lies in the subtle cues and emerging trends that are quietly shaping the future of personal technology. From the corridors of Silicon Valley to the latest tech expos around the globe, whispers of the next big thing are growing louder.

It's not just about more pixels or faster processors; it's a fundamental shift in how we interact with technology.

As you ponder the future of your smartphone, consider this: The clues to its successor are already here, woven into the fabric of our daily tech use. The end of the smartphone era is near, and what's coming next is not just an upgrade – it's a transformation.

The Smartphone Revolution



Image Credit: 19 STUDIO/Shutterstock.© Provided by Viral Chatter

In 2007 ^(ref), the world witnessed the launch of Apple's iPhone, a device that didn't just upgrade existing technology but revolutionized it.

With each iteration, from the iPhone 5s to the current iPhone 14, we've seen enhancements in power, camera quality, and functionality. However, the fundamental design and user interface have remained surprisingly consistent.

This brings us to a critical question: Have we reached the pinnacle of smartphone innovation?

Peak Smartphone: The Crossroads of Technological Evolution

Today, we stand at a crossroads in the evolution of communication technology. We face two possibilities: either smartphones have reached their final form, with only incremental upgrades in the future, or a new, disruptive technology is on the horizon, ready to replace smartphones as we know them.

The pressure is immense on the world's wealthiest companies to innovate and lead us into the next era of communication technology.

The Future of Communication

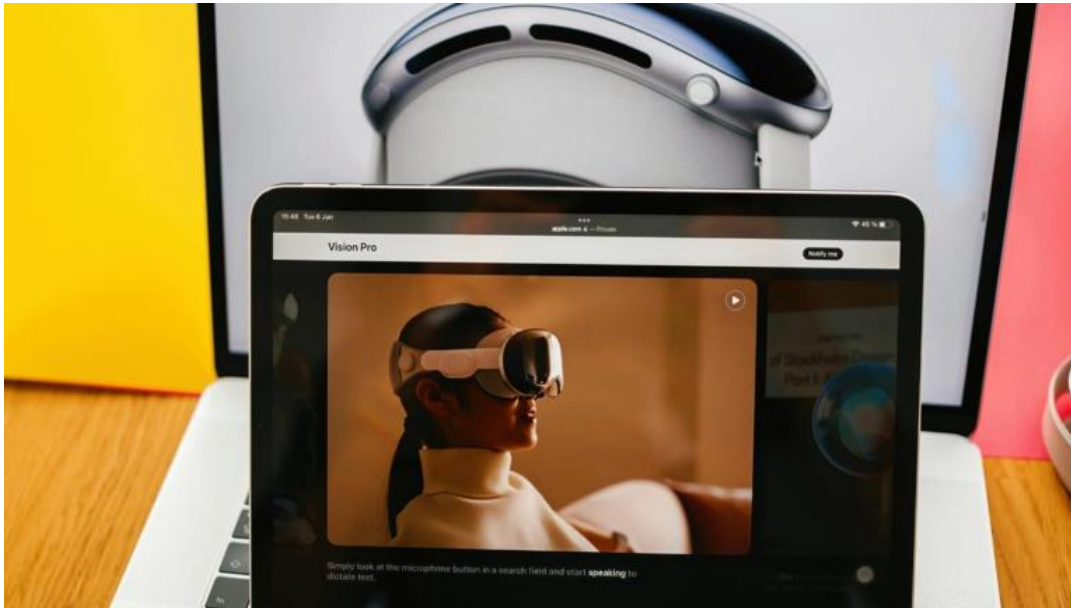


Image Credit: Hadrian/Shutterstock.© Provided by Viral Chatter

The future seems to be gravitating towards augmented reality (AR) and artificial intelligence (AI).

Apple's Vision Pro ^(ref) and Meta's Quest ^(ref) are examples of how technology is moving towards more immersive experiences. These devices aim to integrate digital information seamlessly into our physical world, potentially replacing the traditional smartphone screen with a more dynamic, interactive interface.

AI Pin: A Step Towards Invisible Technology

Companies like Humane Inc are exploring new frontiers with devices like the AI Pin. This wearable device acts as a personal assistant, blending into the background of our lives.

It offers a hands-free experience, projecting information onto surfaces like your hand, and is controlled by voice and gestures.

Representing a shift towards making technology less intrusive and more integrated into our daily experiences.

The Future is Now: Embracing the Next Wave of Tech Innovations

As we ponder over the next big leap in communication technology, it's clear that the future holds exciting possibilities.

Be it smart glasses, AI assistants, or yet-to-be-invented devices, the way we interact with technology is poised for a significant transformation. These innovations promise to make our interaction with technology more natural and integrated, marking another milestone in the ever-evolving journey of communication technology.

World's first bioprocessor uses 16 human brain organoids for 'a million times less power' consumption than a digital chip

[News](#)

By [Mark Tyson](#)

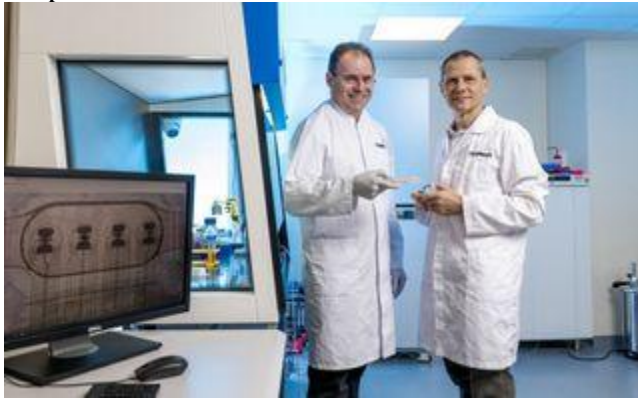
published May 26, 2024

Swiss startup claims its Neuroplatform is a first for biocomputing.

A Swiss biocomputing startup has launched an online platform that provides remote access to 16 human brain organoids. FinalSpark claims its [Neuroplatform](#) is the world's first online platform delivering access to biological [neurons](#) in vitro. Moreover, bioprocessors like this "consume a million times less power than traditional digital processors," the company says.

FinalSpark says its Neuroplatform is capable of learning and processing information, and due to its low power consumption, it could reduce the environmental impacts of

computing. In a recent [research paper](#) about its developments, FinalSparkr claims that training a single LLM like GPT-3 required approximately 10GWh – about 6,000 times greater energy consumption than the average European citizen uses in a whole year. Such [energy expenditure](#) could be massively cut following the successful deployment of bioprocessors.



Founders of FinalSpark, Dr. Fred Jordan and Dr. Martin Kutter (Image credit: FinalSpark)

The operation of the Neuroplatform currently relies on an architecture that can be classified as wetware: the mixing of hardware, software, and biology. The main innovation delivered by the Neuroplatform is through the use of four Multi-Electrode Arrays (MEAs) housing the living tissue – organoids, which are 3D cell masses of brain tissue.

Each MEA holds four organoids, interfaced by eight electrodes used for both stimulation and recording. Data goes to-and-fro via digital analog converters (Intan RHS 32 controller) with a 30kHz sampling frequency and a 16-bit resolution. These key architectural design features are supported by a microfluidic life support system for the MEAs, and monitoring cameras. Last but not least, a software stack allows researchers to input data variables, and then read and interpret processor output.

Image 1 of 3

(Image credit: FinalSpark)

(Image credit: FinalSpark)

(Image credit: FinalSpark)

FinalSpark has given access to its remote computing platform to nine institutions to help spur bioprocessing research and development. With such institutions' collaboration, it hopes to create the world's first living processor. Also, there are already three dozen universities interested in Neuroplatform access.

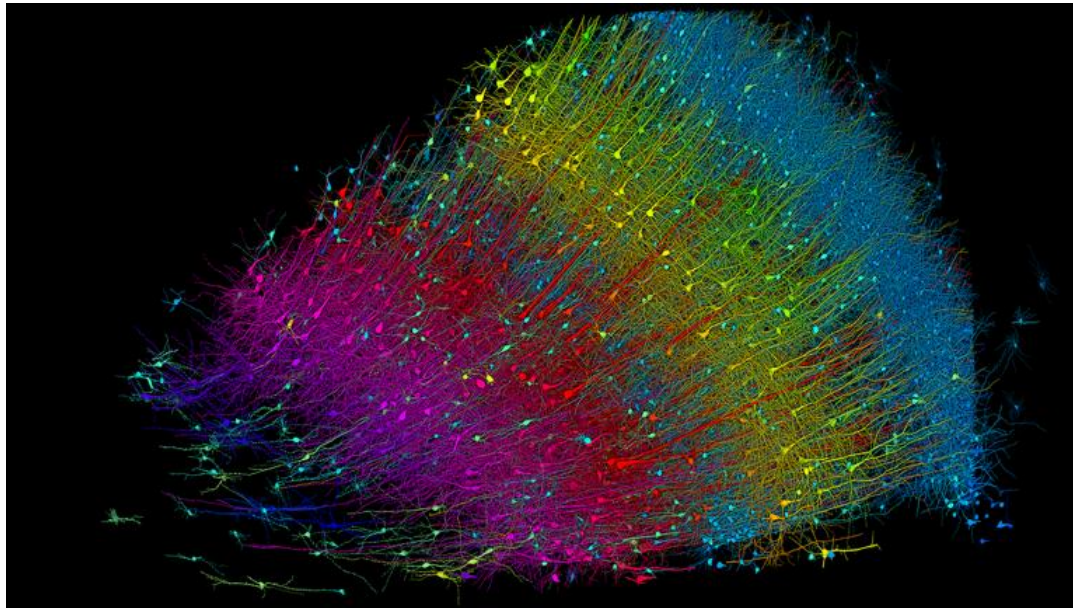
To access the Neuroplatform, educational institutions are asked to subscribe for \$500pcm for each user.

Biological processor organoids 'live' about 100 days

Silicon chips can last years, sometimes [decades](#). The neuronal structures that form bioprocessors are also said to have a long lifespan, but are only “suitable for experiments

that run for several months,” says FinalSpark. Initially, the firm’s MEAs would only last a few hours, but refinements to the system mean an organoid lifespan is currently expected to be around 100 days.

Explore the tiny 'pizza slice' down to the neuron.



Researchers built a 3D image of nearly every neuron and its connections within a small piece of human brain tissue. This version shows excitatory neurons colored by their depth from the surface of the brain. Blue neurons are those closest to the surface, and fuschia marks the innermost layer. The sample is approximately 3 mm wide.© Google Research & Lichtman Lab (Harvard University). Renderings by D. Berger (Harvard University)

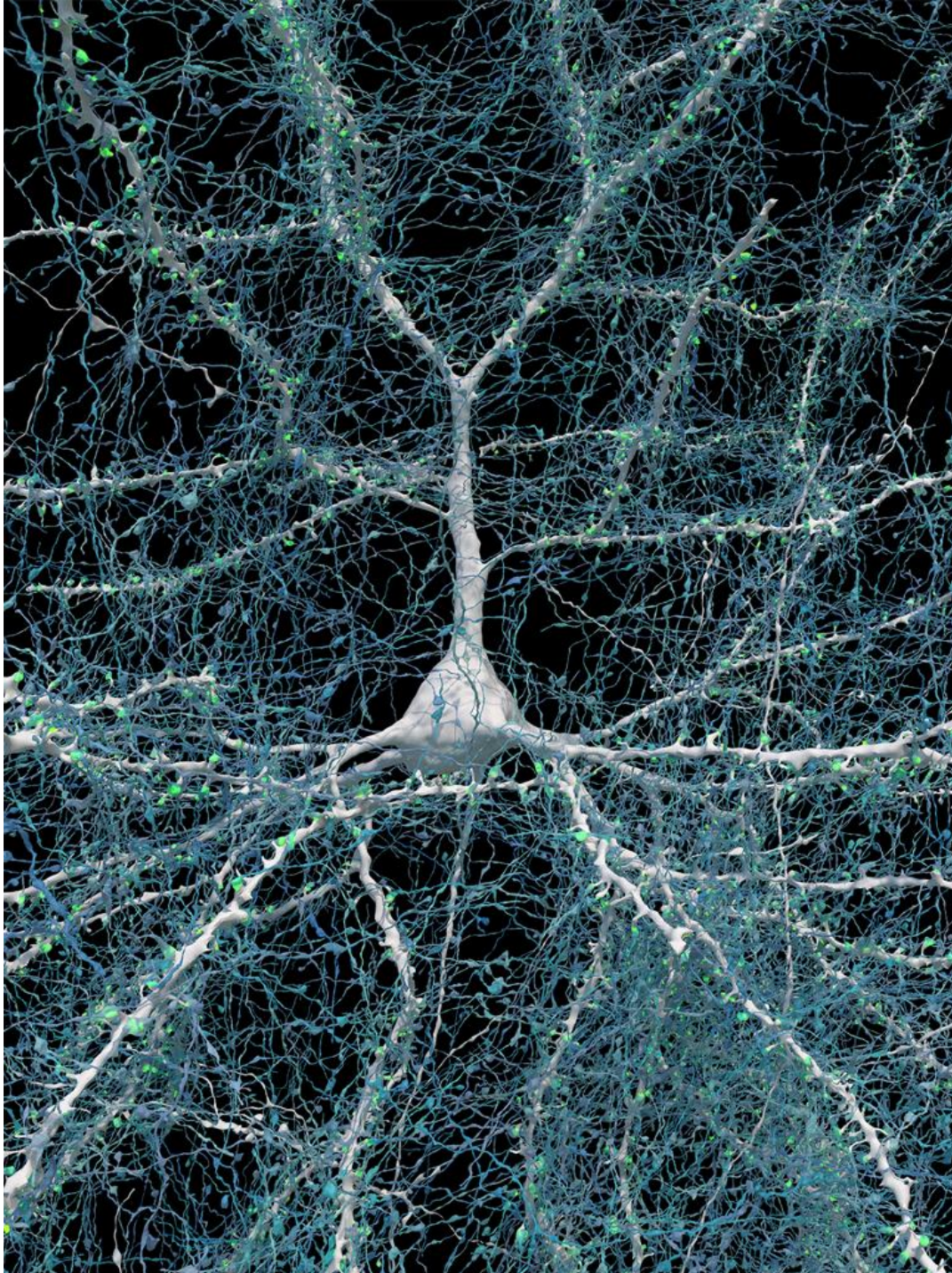
A cubic millimeter is, by all accounts, tiny. It’s barely noticeable—a speck or fleck or crumb. But look closely enough and you can uncover an entire world inside a particle of material. A team of neuroscientists and engineers, aided by machine learning tools, have charted a cubic millimeter volume of the human brain at nanoscale resolution, tracing every neuron, synapse, blood vessel, and supporting cell within the fragment and reconstructing a 3D model of the tissue. Though it represents just one-millionth of the total brain volume, it is the most detailed map of a piece of human brain matter ever created. It could spur a wave of scientific discovery about neurological disorders, brain structure, and the origins of our behavior.

“In one respect, our data set is miniscule,” [Jeff Lichtman](#), co-senior study researcher and a neuroscientist and professor of molecular and cellular biology at Harvard University, tells PopSci. “But it doesn’t feel small because when you get in

it, you see it's like a gigantic forest. It's a very tiny forest, but it's a very, very, very complicated forest," he adds.

A single neuron (white) shown with 5,600 of the axons (blue) that connect to it. The synapses that make these connections are shown in green. The cell body (central core) of the neuron is about 14 micrometers across. Credit: Google Research & Lichtman Lab (Harvard University). Renderings by D. Berger (Harvard University)

All that complexity is on display in a study documenting the construction of this bit of comprehensive brain map or "connectome," [published May 9](#) in the journal Science. The first connectome was of a nematode brain, [completed in 1986](#). Since then, neuroscientists have continued to plot out increasingly large and complicated brains—including those of fruit flies, maggots, a tadpole, and an earthworm. Yet human brains pose a unique mapping challenge in their intricacy and inaccessibility. The new, partial human connectome is [available online](#) for anyone to explore.



See the most detailed map of human brain matter ever created© Provided by Popular Science

"Not only is this an impressive technological feat, this is a tool and a resource that is really aimed at sharing with the world and getting all of this scientific information out there," [Tim Mosca](#), a neuroscientist at Thomas Jefferson University who was uninvolved in the new work, tells PopSci. "This group has done an amazing job designing all of the new tools and the pipelines to make

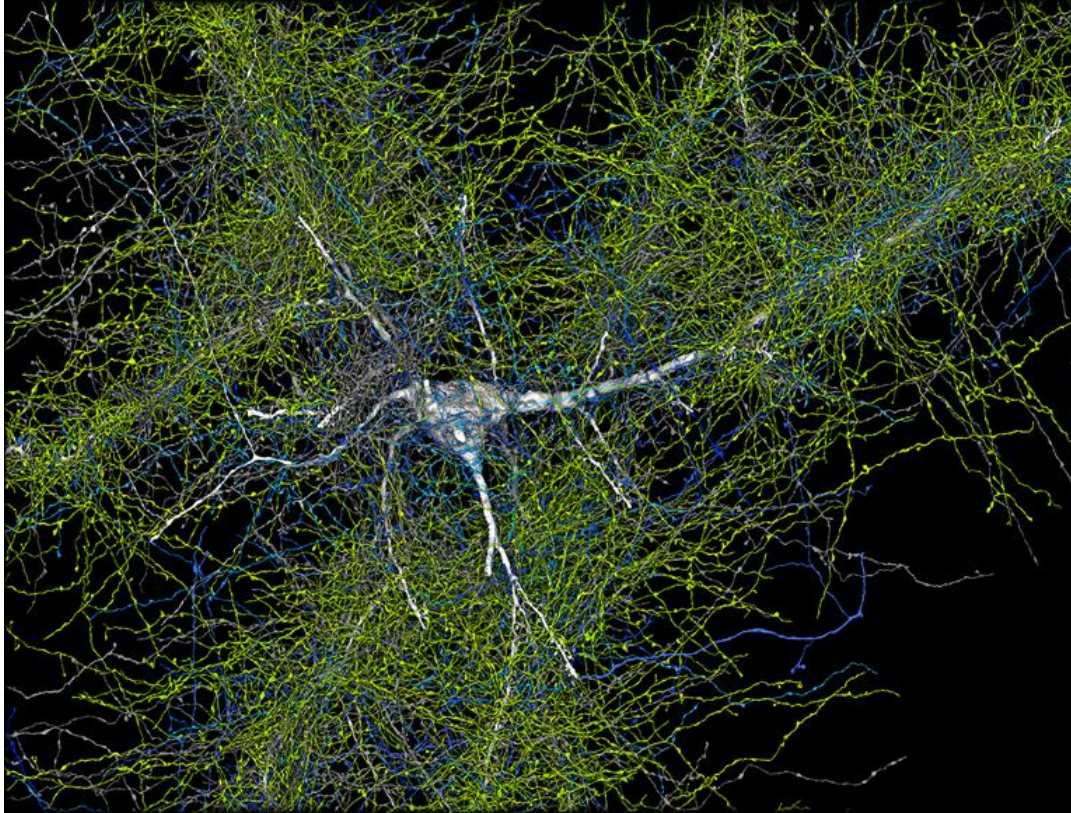
this available to anyone who wants to look at it, wants to think about it, wants to use this in their research.”

A single neuron (white) and all of the axons from other neurons that connect to it. (Green=excitatory axons; Blue=inhibitory axons) Credit: Google Research & Lichtman Lab (Harvard University). Renderings by D. Berger (Harvard University)
Serving up brain pizza

The study sample was collected over a decade ago from an anonymous patient undergoing epilepsy surgery. The surgeon removed a small piece of the temporal lobe to access and treat an underlying lesion, quickly preserved the tissue, and later shared it with scientists. Though the total volume of the fragment is about 1 cubic millimeter, it is not cube shaped. Instead, “it’s like a thick piece of pizza—but it’s not that thick,” says Lichtman. This blunt, triangular chunk, longer than it is wide, enabled the researchers to capture a bit of all six layers of the 3mm thick cerebral cortex.

Researchers built a 3D image of nearly every neuron and its connections within a small piece of human brain tissue. Blue neurons are inhibitory neurons. Red, orange, yellow, and green are excitatory neurons colored by size (red is largest, green is smallest) ranging from 15-30 micrometers across at their cores. The sample is approximately 3 mm long. Credit: Google Research & Lichtman Lab (Harvard University). Renderings by D. Berger (Harvard University)

The first step to mapping the brain pizza was to [slice it](#) into 5,019 individual cross sections (each 30 nanometers thin) mounted on tape using a specially designed machine that cuts with a diamond knife. From there, the researchers spent a full year carefully imaging each slice via electron microscope. Then, they digitally aligned and stitched together the slices and used multiple machine learning tools to fill out the 3-D form and label and color each component.



See the most detailed map of human brain matter ever created© Provided by Popular Science

The segment's neuron density is 16,000 neurons per cubic millimeter— about one-third lower than a previous density estimate of the same brain section and 10 times less dense than the corresponding section of a mouse's brain, per the study. Glial cells, the connective glue that keeps brain tissue together, outnumber neurons in the fragment by a two to one ratio.

Neural explorers

The physical size of the brain fragment may be teeny, but the level of detail means the data captured by the mapping effort is massive. The reconstructed segment is 1.4 petabytes in digital size, or 1,400 terabytes (equivalent to the storage capacity of about 2,800 average laptops). Within that, there is lots to potentially discover: individual neural circuits, previously unobserved cellular ratios and shapes, the makeup of each cortical layer, and more.

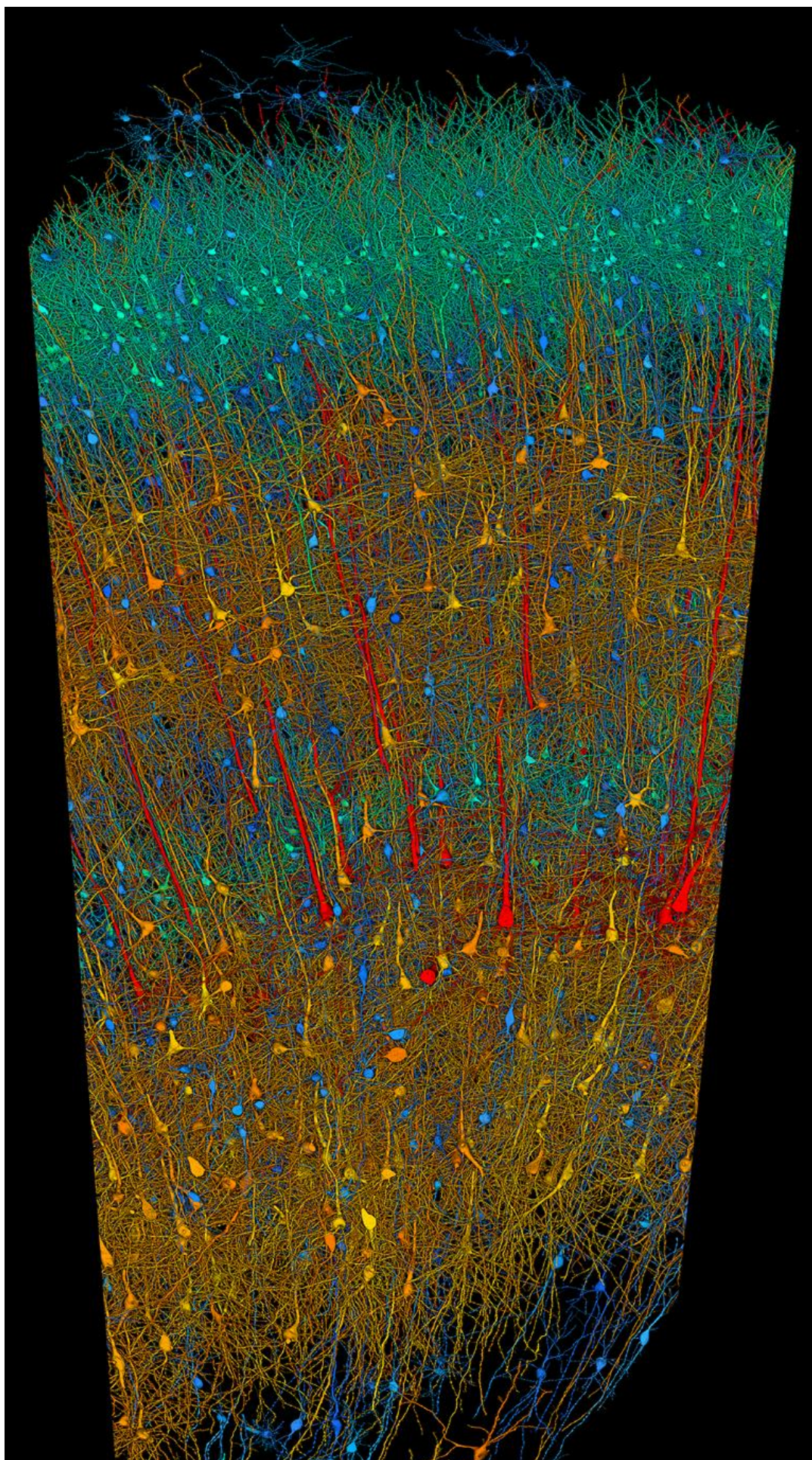
"It's like being an explorer that lands on a new island," says Lichtman. "You keep looking around and you're just going to keep finding new things."

Already, Lichtman and his many co-researchers have made some interesting observations. Amid the ~150 million synapses they mapped, they found a rare type of particularly strong connection. In the vast majority (96.5%) of cases, axons—the outgoing transmission line of neurons—formed one connection with a target cell. Some (about 3%) made 2 connections. But less than .01% forged more than four synapses, including some axons and target cells that were connected at over 50 points.

An image of an axon (blue) climbing up a spiny dendrite (green), establishing an extraordinarily strong connection between an axon and its target cell. Credit: Google Research & Lichtman Lab (Harvard University). Renderings by D. Berger (Harvard University)

“We’ve always had a theory that there would be super connections, if you will, amongst certain cells,” says Mosca. “But it’s something we’ve never had the resolution to prove...Now we know that it exists and we can go after the question of what it does.” Lichtman’s current hypothesis is that these extra-fortified connections are the sort of hyper-fast pathways that enable “automatic use of the brain” for well-established, learned actions.

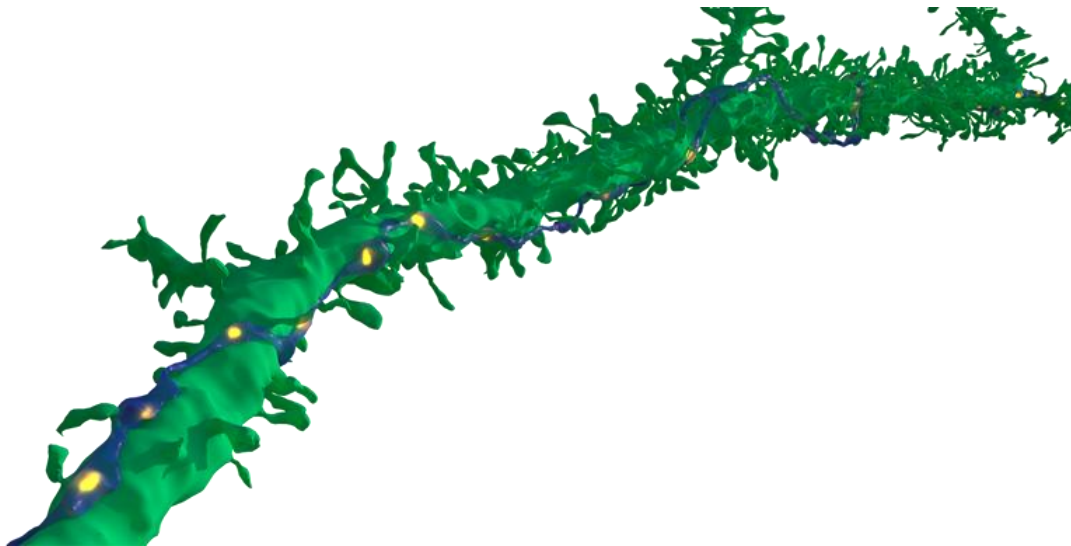
Another new observation: many dendrites (the branching extensions of neurons that generally receive inputs) seem to mirror each other—pointing symmetrically in one of just two directional arrangements out of infinite three-dimensional possibilities. “We’d never seen anything like that [before],” says Lichtman. “Why are they doing that? We don’t know... [it is] a complete mystery.”



See the most detailed map of human brain matter ever created© Provided by Popular Science

An intriguing finding in the reconstruction was the existence of clusters of cells that tended to occur in mirror-image orientation to one another. This image shows a particularly symmetric pair. Credit: Google Research & Lichtman Lab (Harvard University). Renderings by D. Berger (Harvard University)

The scientists further found a new type of unexplained structure that they've named an "axon whorl," wherein long axon cables appear to tangle around themselves. Though it wasn't every neuron, some axons contained multiple knots, says [Viren Jain](#), co-senior study author and a senior staff scientist at Google where he leads the company's [Connectomics](#) research team. Again, the function and cause of these whorls is unknown. "We were not expecting to find such a structure. It's very peculiar... like a big jumble of wiring that sort of contravenes the purpose of a wire to begin with, which is to go places and contact other things."

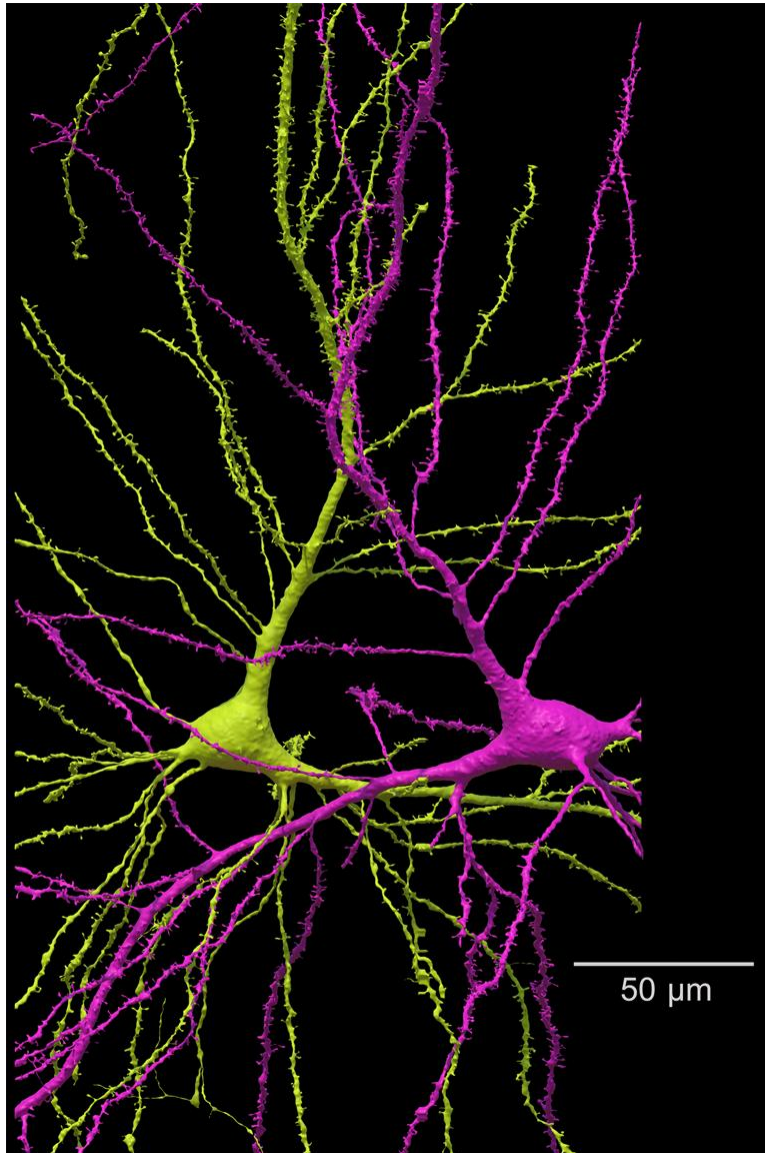


See the most detailed map of human brain matter ever created© Provided by Popular Science

surprising finding in this research was the occurrence of "axon whorls". Axons (blue) are the filamentous part of a nerve cell that carries a signal away from the cell. These looped piles of axon were rare in the sample, and in some cases they sat on the surface of another cell (yellow). Their function is unknown. Credit: Google Research & Lichtman Lab (Harvard University). Renderings by D. Berger (Harvard University)

These three findings are likely just the tip of the iceberg. "The data set is so large that one human being or lab group can not explore it [all], but a bunch of human

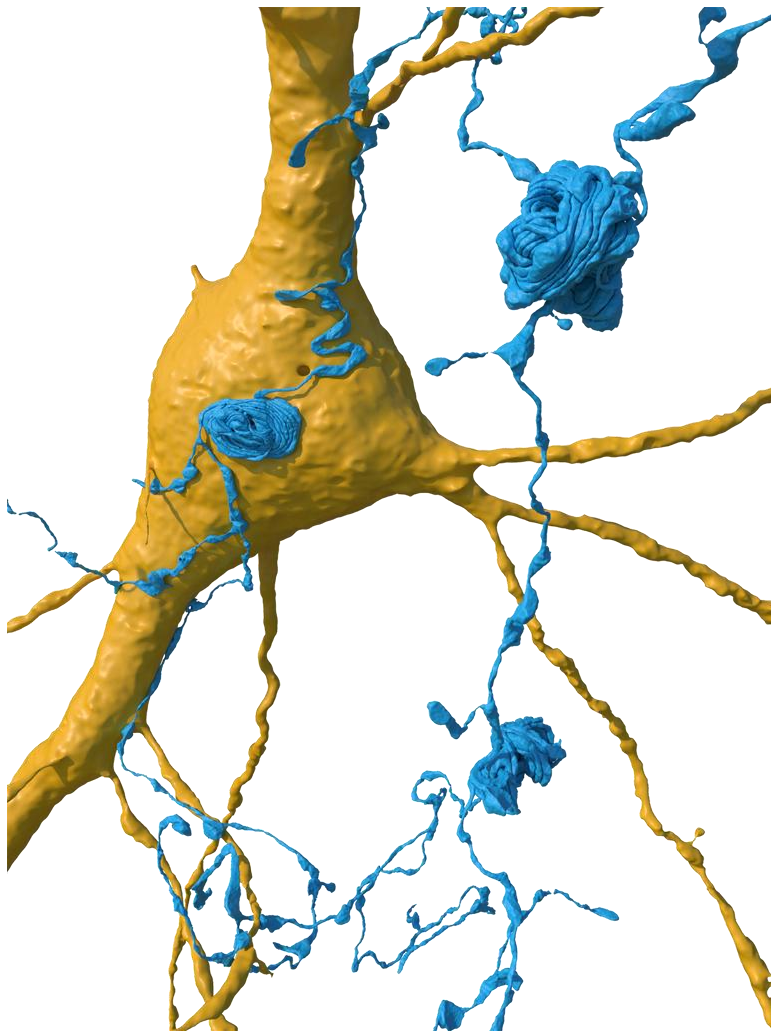
beings can,” Lichtman says. Because of the open nature of the project, more than [200 papers](#) have cited the brain reconstruction since it was first released as a pre-print, Jain points out.



See the most detailed map of human brain matter ever created© Provided by Popular Science

In addition to being a large, fundamental advance in science, discoveries resulting from this partial connectome could eventually help us better understand and treat brain diseases. “The ability to measure neural wiring of human brains in such detail opens up exciting opportunities for advancing human health,” says [Andrew Leifer](#), a physicist and neuroscientist at Princeton University who wasn’t involved in the project. “One could imagine comparing

different brains to understand how brain wiring changes when a healthy brain suffers from a disease or falls into dysfunction,” he adds.



See the most detailed map of human brain matter ever created© Provided by Popular Science

Pushing into future frontiers

But though there is lots to be discovered, there are also limits. The automated machine learning methods which were key to enabling such a large-scale endeavor carry a margin of error that requires human oversight to correct. Editing will be an ongoing project, and is a community science effort anyone who wants to can [apply to participate in](#).

The sample is also only one small piece of one person's brain. There is much that can't yet be inferred about human brains generally or other brain regions beyond the temporal lobe based on this single fragment without more samples and maps for comparison, notes Lichtman.

This rendering shows all of the excitatory (pyramidal) neurons in a part of the brain sample, at varying degrees of magnification and tilt. They are colored by size; the cell body (central core) of the cells ranges from 15-30 micrometers across. Credit: Google Research & Lichtman Lab (Harvard University). Renderings by D. Berger (Harvard University)

And, perhaps most critically, the brain segment came from someone undergoing surgery for epilepsy—it may not represent a “normal” brain and there’s no way to know for sure unless and until we have more bits to assess, say Jain and Lichtman. “But we are planning many follow-ups to this,” Jain adds.

The team has ambitions to construct multiple partial connectomes representing additional human brain samples. They are also working on zebrafish connectome, and are planning to tackle increasingly large segments of the mouse brain. Mammalian brains share many similarities, so a complete mouse connectome could offer new insights into our own brain as well as the evolution of brains across animals, Lichtman says.

See the most detailed map of human brain matter ever created© Provided by Popular Science

At the moment, with currently available technologies (and the ethical implications), a complete connectome of the human brain is “a bridge too far,” says Lichtman. “Literally, we’re a million times away from that,” says Jain. But through this study, the scientists have taken an early (if miniscule) step in that direction, and even the smallest peephole can be a portal into a whole universe of knowledge.

“I would love people to think about this the same way they think about the Hubble or James Webb telescope,” says Lichtman. “We’re peering into an unknown domain, and one that is much more relevant to us than distant outer space. It’s this inner space that each of us have on our shoulders that we use, but know almost nothing about.”



Solos© Provided by Digital Trends

Solos, the company behind the [AirGo 3 smart glasses](#), continues to add new functionality to the cutting-edge wearable. The latest update is a live search feature where you can ask the AI-powered smart glasses a series of questions following a tap of the frame to wake the system up. Because it understands context, you can phrase your questions naturally.

The Solos smart glasses come in several different styles and are audio smart glasses, unlike [Ray-Ban Meta](#) smart glasses, which incorporate a camera. What makes them stand out in comparison is that the “smart” technology is built into the arms, allowing you to change the face and lenses at will. This allows you to use the AirGo3 glasses for everyday, sport, or casual wear without losing functionality.

The Live search update uses Solos’s own SolosChat software and AI services like ChatGPT. Solos suggests use cases, including searching for prices and information on products when out shopping or as a tour guide in a new location. The smart glasses will follow the conversation without you having to repeat or specifically phrase questions to get an answer.



Solos© Provided by Digital Trends

Kenneth Fan, co-founder at Solos, said:

“By adding live search to smart glasses, we’re allowing people to have the power of an AI assistant and teach engine instantly available anytime with just a natural voice interface. Our open and modular technology architecture enable Solos to integrate the latest innovations in artificial intelligence and software services.”

Live Search joins other AI software features, including live translation, text-to-speech support for messages, and access to an AI assistant to help with organization and work. Live Search will be added through an over-the-air software update that will be delivered to the smart glasses starting today. Solos AirGo 3 smart glasses start at \$199 and are available in several different styles and colors, with the option to add prescription lenses.

An [AI assistant](#) is available for the Ray-Ban Meta smart glasses in the U.S. It makes use of the camera to provide more information on your surroundings. Ray-Ban Meta smart glasses also come in different styles and colors, with or without prescription lenses, and start at \$299.



Tiny startup bets that you will spend \$2000 on a work 'laptop' with no screen — Spacetop G1 uses AR glasses to deliver a virtual 100-inch display but it runs on Google ChromeOS© Sightful

After nearly three years in development, Sightful has unveiled Spacetop G1, the world's first Augmented Reality laptop which uses AR glasses to deliver a virtual 100-inch display and runs on Chrome OS.

Currently priced at \$1700 (it usually retails at \$1900), the Spacetop G1 is [available to reserve for a \\$100 refundable deposit](#) and is expected to start shipping in October 2024. It's US-only for now.

Developed by a team of over 60 spatial computing experts, including veterans from Apple, Microsoft, and Magic Leap, Spacetop offers a private, virtual workspace. The laptop form factor houses customized hardware and a proprietary spatial environment, allowing users to design and customize their workspace wherever they are.

Tethered AR glasses

The Spacetop G1 measures 0.51 inches tall, 2.44 inches wide, 11.81 inches deep, and weighs 3.08 lbs. It runs on the Qualcomm Snapdragon QCS8550 platform

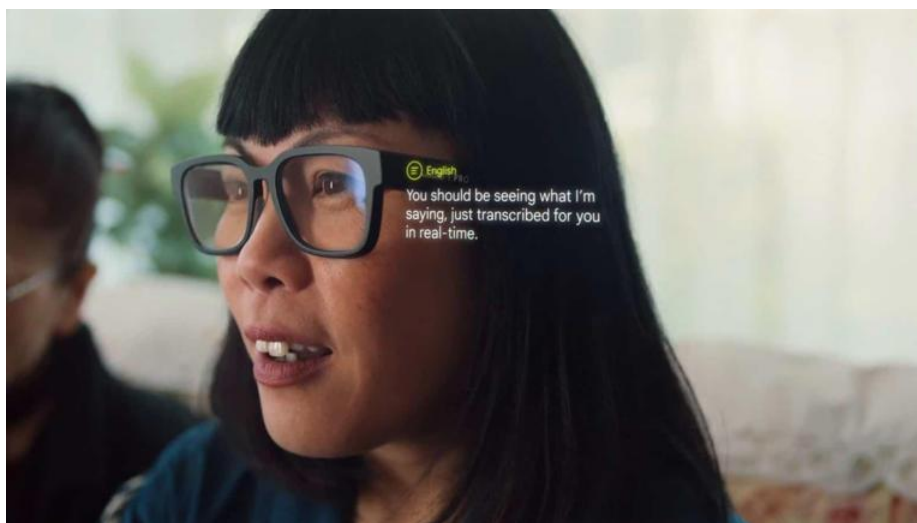
with a KRYO CPU and Adreno 740 graphics, and comes with 16GB LPDDR5 memory and 128GB UFS3.1 storage.

The G1 features two USB-C ports and connectivity options include Wi-Fi 7, 5G (there's support for a Nano-SIM and eSIM) and Bluetooth 5.3. The 60Wh battery promises up to 8 hours of life, or a "full day's work" as the company puts it.

The G1 integrates NReal glasses with the proprietary Spacetop environment, providing clear, high-resolution AR windows overlaid onto the real world. The glasses, which attach to the laptop, weigh 0.18 lbs and come with two OLED display panels (1920x1080 pixels per eye) with a 90Hz refresh rate and a 50° diagonal field of view. Custom prescription lenses are available from -8.00D to +6.00D.

It will be interesting to see if businesses are ready to embrace the concept of a screenless AR laptop like the Spacetop G1, especially given its high price point.

"Laptops are essential to our daily working lives, yet the technology hasn't evolved to match the modern 'work from anywhere' mentality," said Tamir Berliner, CEO and co-founder of Sightful. "Meanwhile, Augmented Reality holds promise but lacks a daily use case. Spacetop G1 is the first step towards a new paradigm."



Google IO 2022 smart glasses prototype© Provided by Android Headlines

Science fiction has been the cradle of multiple ideas that today are reality, while others seem much more possible than before. Until relatively recently, a decent VR experience was impossible or very cumbersome to enjoy. Another advanced technology that seems more viable today is AR glasses that replace your phone, and [Apple](#) would be looking for it.

According to Bloomberg, Apple is [restarting](#) a project to develop advanced AR glasses. These would be much [lighter](#) than the [Apple Vision Pro](#), whose ergonomics are not its best virtue. However, the company would like you to be able to use the glasses all day, so they would have fairly contained dimensions. Its format would be similar to that of the [Google Glass](#) project from years ago.

Apple's AR glasses could fully replace your iPhone

Apple already boasts of having a lot of experience in AR-based UX thanks to the development of the Vision Pro. According to the report, some of the Vision Pro technologies would be implemented in the lightweight AR glasses. Internally, a release date of 2027 has even been discussed. However, the source adds that even the development team sees that deadline as unlikely.

Why Apple is Quietly Buying AI Companies

Apple has yet to decide whether to invest in everything that a project of this magnitude requires. The company must study the profitability that AR glasses capable of replacing iPhones would bring. So, they must consider key items such as development cost, public interest, and price for the user, among others. The company will surely be quite cautious after the [failure in sales](#) of its Vision Pro.

Apple has yet to decide on the viability of the project

Vision Products Group is the team in charge of all the company's "Vision" projects. Recent reports suggest that they are focusing on a more [affordable](#)

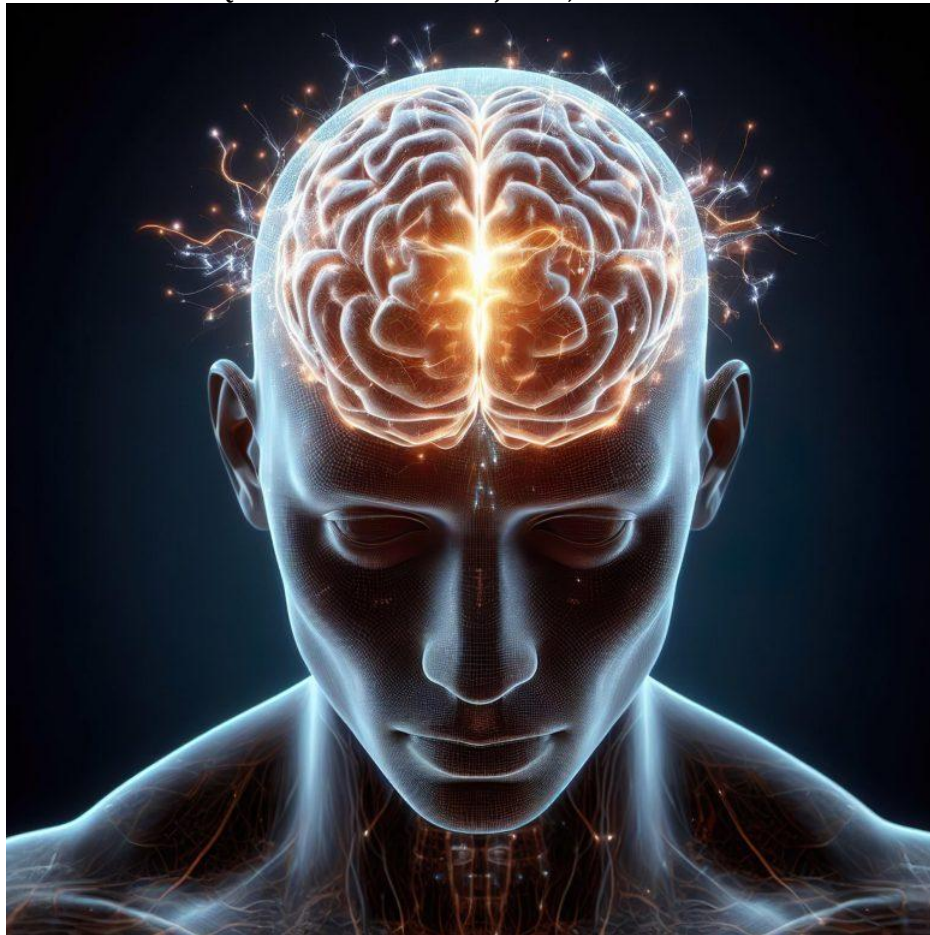
[Vision headset](#). Bloomberg claims that the team will decide on the viability of AR glasses as they work on other things.

In its day, the Google Glass project had many factors that influenced [its failure](#). Probably the most important factor was the starting price of \$1,500. However, there were also serious regulatory challenges due to its video recording capabilities. It will be interesting to see if potential Apple AR glasses manage to overcome these challenges in the future.

SciTechDaily

Neuroscience Breakthrough: A Non-Invasive New Therapy for Addiction, Depression, and OCD

BY ECOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE JUNE 27, 2024



EPFL researchers are advancing non-invasive brain stimulation methods to target and modify deep brain regions involved in neurological disorders. Their innovative approach offers potential for less

invasive, personalized treatments with wide applicability and minimal side effects. Credit: SciTechDaily.com

Researchers at EPFL have effectively tested a new method that allows for deep exploration of the human brain without the need for surgery, with potential applications in therapy.

Neurological disorders like addiction, depression, and obsessive-compulsive disorder (OCD) impact millions globally, presenting with complex pathologies that involve several brain regions and circuits. Treating these conditions is particularly challenging due to the complex and not well-understood functions of the brain, along with the difficulty of administering therapies to deep brain structures in a non-invasive way.

In the rapidly evolving field of neuroscience, non-invasive brain stimulation is a new hope for understanding and treating a myriad of neurological and psychiatric conditions without surgical intervention or implants. Researchers, led by Friedhelm Hummel, who holds the Defitchech Chair of Clinical Neuroengineering at EPFL's School of Life Sciences, and postdoc Pierre Vassiliadis, are pioneering a new approach in the field, opening frontiers in treating conditions like addiction and depression.

Research Highlights and Technique Description

Their research, leveraging transcranial Temporal Interference Electric Stimulation (tTIS), specifically targets deep brain regions that are the control centers of several important cognitive functions and involved in different neurological and psychiatric pathologies. The research, published in the journal *Nature Human Behaviour*, highlights the interdisciplinary approach that integrates medicine, neuroscience, computation, and engineering to improve our understanding of the brain and develop potentially life-changing therapies.

"Invasive deep brain stimulation (DBS) has already successfully been applied to the deeply seated neural control centers in order to curb addiction and treat Parkinson's, OCD, or depression," says Hummel. "The key difference with our approach is that it is non-invasive, meaning that we use low-level electrical stimulation on the scalp to target these regions."

A model image of the targeted deep brain zone, the striatum, a key player in reward and reinforcement mechanisms. Credit: EPFL

Vassiliadis, lead author of the paper, a medical doctor with a joint PhD, describes tTIS as using two pairs of electrodes attached to the scalp to apply weak electrical fields inside the brain. "Up until now, we couldn't specifically target these regions with non-invasive techniques, as the low-level electrical fields would stimulate all the regions between the skull and the deeper zones—rendering any treatments ineffective. This approach allows us to selectively stimulate deep brain regions that are important in neuropsychiatric disorders," he explains.

The innovative technique is based on the concept of temporal interference, initially explored in rodent models, and now successfully translated to human applications by the EPFL team. In this experiment, one pair of electrodes is set to a frequency of 2,000 Hz, while another is set to 2,080 Hz. Thanks to detailed computational models of the brain structure, the electrodes are specifically positioned on the scalp to ensure that their signals intersect in the target region.

Exploring the Human Striatum

It is at this juncture that the magic of interference occurs: the slight frequency disparity of 80 Hz between the two currents becomes the effective stimulation frequency within the target zone. The brilliance of this method lies in its selectivity; the high base frequencies (e.g., 2,000 Hz) do not stimulate neural activity directly, leaving the intervening brain tissue unaffected and focusing the effect solely on the targeted region.

The focus of this latest research is the human striatum, a key player in reward and reinforcement mechanisms. “We’re examining how reinforcement learning, essentially how we learn through rewards, can be influenced by targeting specific brain frequencies,” says Vassiliadis. By applying stimulation of the striatum at 80 Hz, the team found they could disrupt its normal functioning, directly affecting the learning process.

An illustrative image of the striatum, a critical region in the brain involved in reward and reinforcement processes. Credit: EPFL

The therapeutic potential of their work is immense, particularly for conditions like addiction, apathy, and depression, where reward mechanisms play a crucial role. “In addiction, for example, people tend to over-approach rewards. Our method could help reduce this pathological overemphasis,” Vassiliadis, who is also a researcher at UCLouvain’s Institute of Neuroscience, points out.

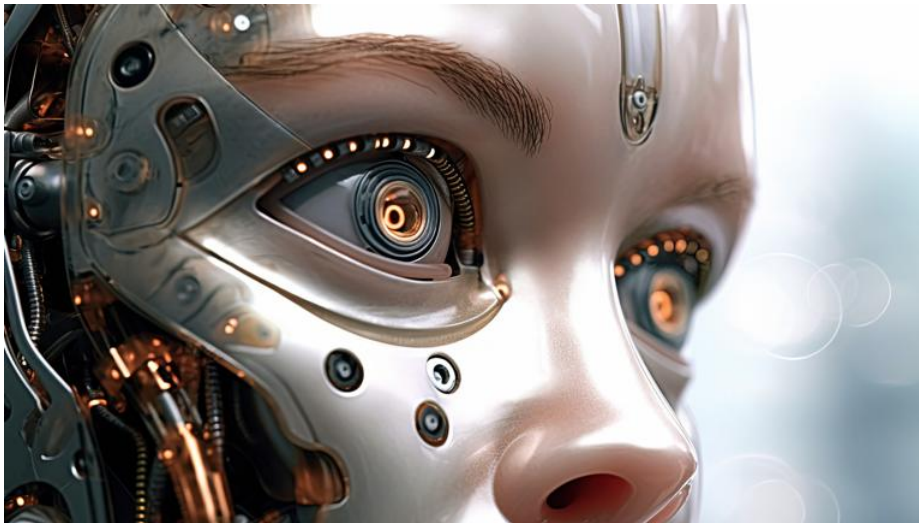
Furthermore, the team is exploring how different stimulation patterns can not only disrupt but also potentially enhance brain functions. “This first step was to prove the hypothesis of 80 Hz affecting the striatum, and we did it by disrupting its functioning. Our research also shows promise in improving motor behavior and increasing striatum activity, particularly in older adults with reduced learning abilities,” Vassiliadis adds.

Hummel, a trained neurologist, sees this technology as the beginning of a new chapter in brain stimulation, offering personalized treatment with less invasive methods. “We’re looking at a non-invasive approach that allows us to experiment and personalize treatment for deep brain stimulation in the early stages,” he says. Another key advantage of tTIS is its minimal side effects. Most participants in their studies reported only mild sensations on the skin, making it a highly tolerable and patient-friendly approach.

Hummel and Vassiliadis are optimistic about the impact of their research. They envision a future where non-invasive neuromodulation therapies could be readily available in hospitals, offering a cost-effective and expansive treatment scope.

Reference: “Non-invasive stimulation of the human striatum disrupts reinforcement learning of motor skills” by Pierre Vassiliadis, Elena Beanato, Traian Popa, Fabienne Windel, Takuya Morishita, Esra Neufeld, Julie Duque, Gerard Derosiere, Maximilian J. Wessel and Friedhelm C. Hummel, 29 May 2024, *Nature Human Behaviour*.

DOI: [10.1038/s41562-024-01901-z](https://doi.org/10.1038/s41562-024-01901-z)



Robot with lab-grown brain developed in China, performs critical tasks© Provided by Interesting Engineering

Researchers at China’s Tianjin University and the Southern University of Science and Technology have reportedly developed a robot with a lab-grown artificial brain.

Brain-on-chip technology has been used to train the machine to perform various tasks, according to local media.

Scientists reportedly combined brain organoid with a neural interface chip to power the complex machine. The robot has been trained to easily grip objects and avoid obstacles, according to Tianjin University.

In-vitro cultured ‘brain’

In general, brain organoids are in vitro three-dimensional aggregates created through the self-organization and differentiation of [human pluripotent](#) stem cells. They can become brain-like tissues that recapitulate aspects of a developing brain’s structure.

Ming Dong, vice-president of Tianjin University, stated that it’s a technology that uses an in-vitro cultured ‘brain’ – such as brain organoids – coupled with an electrode chip to form a brain-on-chip, reported SCMP.

Hybrid human-robot intelligence

Brain on chip technology is part of brain-computer interfaces that combine brain’s electrical signals with external computing power. It recently got a widespread attention after Elon Musk launched [Neuralink](#) chip, a brain-computer interface that is fully implantable, cosmetically invisible, and designed to let you control a computer or mobile device anywhere you go.

Brain-like computing

Researchers claimed that it is “the world’s first open-source brain-on-chip [intelligent](#) complex information interaction system” and could lead to the development of brain-like computing.

In their recent paper published in Oxford University Press journal [Brain](#), they stated that human brain organoids represent a remarkable platform for modeling neurological disorders and a promising brain repair approach. However, the effects of physical stimulation on their development and integration remain unclear.

Li Xiaohong, a professor at Tianjin University, stated that while brain organoids were regarded as the most promising model of basic intelligence, the technology still faced “bottlenecks such as low developmental maturity and insufficient nutrient supply”, according to [SCMP](#).

In their paper, the team wrote that low-intensity ultrasound stimulation advances the development and integration of [brain organoids](#), providing a strategy for treating neurodevelopmental disorders and repairing cortical damage.

Following organoid graft transplantation into the injured somatosensory cortices of adult mice, longitudinal electrophysiological recordings and histological assays reveal that ultrasound-treated organoid grafts undergo advanced maturation, said [researchers](#).

The university also said the team's use of non-invasive low-intensity ultrasound treatment could help neural networks form and mature, providing a better foundation for computing, according to the [media report](#).

A new study has uncovered the pivotal role of a brain structure called the claustrum in regulating engagement, from deep sleep to waking behavior.

The research paper, titled "[Clastrum Neurons Projecting to the Anterior Cingulate Restrict Engagement During Sleep and Behavior](#)," is published in *Nature Communications*.

The findings shed new light on how our brains control responsiveness to sensory stimuli, potentially revolutionizing our understanding of attention, impulse control, and even sleep disorders.

The researchers recorded the activity of neurons in the claustrum of mice during an attention-demanding task. They discovered that increased activity in these neurons reduces sensory responsiveness and reduces impulsivity. Performing similar experiments during sleep also identified a role for claustrum neurons in supporting uninterrupted sleep.

Conversely, lower activity of claustrum neurons was linked to hyper-engagement and impulsive errors. In fact, by enhancing the activity of these neurons, the researchers could reduce both impulsive errors when mice perform a task, as well as the probability that mice will awake in response to sensory stimulation. These

results highlight the claustrum's regulatory function during different arousal states.

The study was led by Prof. Ami Citri, Dr. Gal Atlan, and a team from The Edmond and Lily Safra Center for Brain Sciences at the Hebrew University (ELSC), in collaboration with the research group led by Prof. Yuval Nir at Tel Aviv University.

"Our study provides compelling evidence that claustrum neurons act as gatekeepers of engagement, regulating how likely perception is to drive action," says lead researcher Prof. Ami Citri.

"Understanding these mechanisms could offer new insights into a wide range of neurological and psychiatric disorders characterized by impaired impulse control such as ADHD, OCD, drug addiction, schizophrenia and other disorders...."

"This study enhances our understanding of the claustrum's function in brain processes and opens potential pathways for addressing issues related to attention disorders and sleep disturbances," says Prof. Citri.

"It provides valuable insight into how specific neural pathways influence behavioral states, advancing our knowledge of the complex interactions between sleep and alertness, and could lead to targeted therapeutic interventions."

More information: Gal Atlan et al, Claustrum neurons projecting to the anterior cingulate restrict engagement during sleep and behavior, *Nature Communications* (2024). DOI: [10.1038/s41467-024-48829-6](https://doi.org/10.1038/s41467-024-48829-6)



digital brain connections, map of brain© Provided by BGR

A group of Chinese researchers has created a robot with a brain made of human stem cells. The technology is technically a "brain-on-a-chip," and the researchers have been working to train the robot to perform various tasks. The stem cell brain that powers the robot is attached to a neural interface chip, which powers the entire thing.

[Tianjin University](#), one of the two institutes behind the new research, considers the design the world's first open-source brain-on-chip system and says that it could lead to the development of more brain-like computing. The key to the entire design is an in-vitro cultured brain organoid.

That organoid has been coupled with an electrode chip to form the basis of the brain-on-chip. In this case, the organoid is made up of stem cells, effectively making it a stem cell brain. This kind of technology is part of an emerging trend that scientists are calling brain-computer interface.



stem cell brain robot© Provided by BGR

Perhaps one of the most well-known BCIs out there right now, [Neuralink](#), has garnered attention because of its backing from Elon Musk and its ability to be implanted directly in the brain. By putting their brains into a robot, though, the researchers behind this latest development are looking to expand what their BCI can do.

Instead of relying on human interaction, the researchers trained the stem cell brain to use the robot's various parts to pick up items and move them around. From there, Tianjin University hopes to lead future research and development into hybrid human-robot intelligence.

The university also shared photos of the robot, which features a brain-like organ on top of its head. However, the information says that this organoid is just for show and not the actual brain that is controlling the robot. Still, it's quite the look, and if it is as capable as the researchers say, perhaps we will see more advanced BCI-powered robots coming out in the next couple of years.

The Sci-Fi Future is Now: 8 Ways AI Brain Chips Will Change Everything

Imagine controlling a drone with your thoughts or “downloading” skills directly into your brain, like Neo learning kung fu through a brain chip in *The Matrix*. While this may sound like something straight out of a science fiction movie, recent advancements in AI and brain-computer interfaces (BCIs) are rapidly turning these far-fetched ideas into reality.

As this technology becomes more sophisticated and accessible, it has the potential to revolutionize fields like medicine, education, and even entertainment.

Here are 8 futuristic applications of AI-human brain interfaces that will blow your mind.

1. Restoring Speech & Movement for Paralyzed Patients

For individuals who have lost the ability to speak or move due to paralysis or brain injuries, AI brain chips offer a glimmer of hope.

Through converting brain signals into text or commands for prosthetic limbs,^(ref) these implants can give a voice to the voiceless and restore independence.

2. Enhancing Cognitive Abilities & Memory

What if you could boost your brainpower with a simple implant? AI brain chips have the potential to augment focus, memory, and learning capabilities by directly interfacing with specific regions of the brain.^(ref)

While the ethical implications of cognitive enhancement must be carefully considered, this technology could open up new possibilities for personal and professional growth.

3. Enabling Telepathic Communication

Brain-to-brain communication may sound like something straight out of the X-Men, but it's not as far-fetched as you might think.

Researchers at the University of Washington have already demonstrated a method for allowing one person to control another's hand movements using their brain signals.^(ref) As this technology advances, we may see a future where thoughts and ideas can be shared seamlessly between individuals.

4. Creating Immersive Virtual & Augmented Reality Experiences

Imagine being able to fully immerse yourself in a virtual world or overlay digital information onto your real-world surroundings – all without the need for bulky headsets or glasses.

AI brain chips could enable users to interact with virtual and augmented reality environments using only their thoughts, creating more natural and intuitive experiences.^(ref)

5. Treating Mental Health Disorders

US military-funded researchers are developing AI brain implants that can detect patterns related to mood disorders and shock the brain back into a healthy state without the need for a physician.^(ref) By providing real-time neurofeedback, these closed-loop systems could offer new hope for individuals struggling with conditions like depression and anxiety.

6. Controlling Machines & Robots with Thought

Imagine being able to control complex machinery or robots with just a thought. AI brain chips could enable workers to operate equipment more efficiently and safely, without the need for physical controls. This technology could also have applications in fields like space exploration, allowing astronauts to remotely control rovers and other equipment on distant planets.

7. Enhancing Sensory Experiences

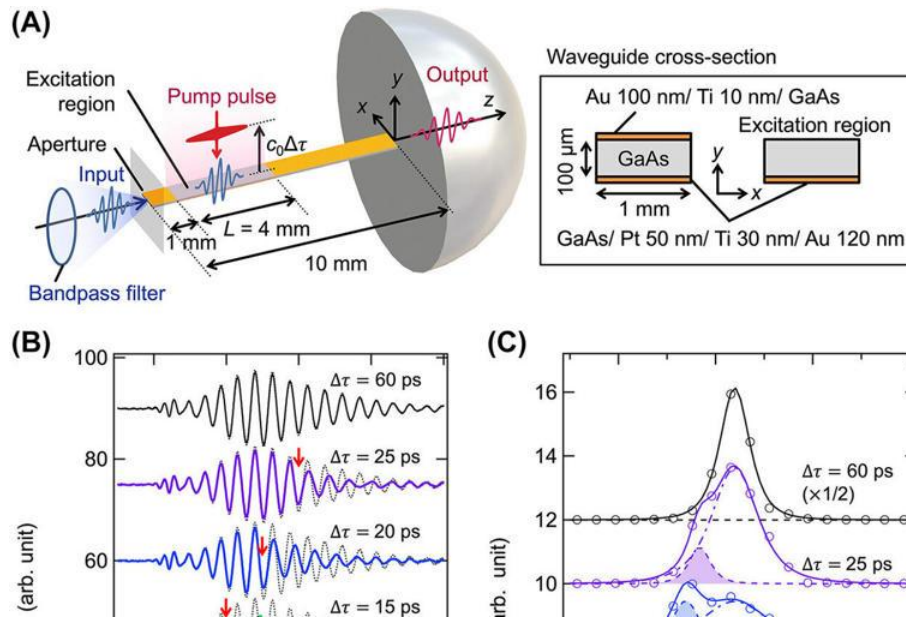
AI brain implants could potentially be used to enhance or even create new sensory experiences. Through stimulating specific areas of the brain, these devices could allow users to see colors they've never seen before, hear new frequencies of sound, or feel sensations that are difficult to describe.

The implications of sensory enhancement are still largely unknown, but it's an exciting area of research with endless possibilities.

8. Digitally Recording & Sharing Memories

What if you could save your favorite memories and experiences to a digital archive, or even share them with others?

AI brain chips could one day make it possible to record and store a person's life experiences, creating a kind of "digital diary" that could be accessed and relived at any time. While the privacy implications of this technology are significant, it could also have applications in fields like education and historical preservation.



Experimental setup and observed terahertz waves. Credit: Nanophotonics (2024). DOI: 10.1515/nanoph-2024-0010© Provided by Phys.org

Terahertz technology could help us meet the ever-increasing demand for faster data transfer rates. However, the down-conversion of a terahertz signal to arbitrary lower frequencies is difficult.

In a recent study, researchers from Japan have developed a new strategy to up- and down-convert a terahertz signal in a waveguide by dynamically modifying its conductivity using light, creating a temporal boundary. Their findings could pave the way to faster and more efficient optoelectronics and enhanced telecommunications.

As we plunge deeper into the Information Age, the demand for faster data transmission keeps soaring, accentuated by fast progress in fields like deep learning and robotics. Against this backdrop, more and more scientists are exploring the potential of using terahertz waves to develop high-speed telecommunication technologies.

However, to use the terahertz band efficiently, we need frequency division multiplexing (FDM) techniques to transmit multiple signals simultaneously. Of course, being able to up-convert or down-convert the frequency of a terahertz

signal to another arbitrary frequency is a logical prerequisite to FDM. This has unfortunately proven quite difficult with current technologies.

The main issue is that terahertz waves are extremely high-frequency waves from the viewpoint of conventional electronics and very low-energy light in the context of optics, exceeding the capabilities of most devices and configurations across both fields. Therefore, a radically different approach will be needed to overcome current limitations.

Surprisingly, in a study [published in *Nanophotonics*](#) on May 20, 2024, a research team including Assistant Professor Keisuke Takano from the Faculty of Science, Shinshu University, Japan, report an innovative solution for the frequency down-conversion of terahertz waves.

Their paper was co-authored by Fumiaki Miyamaru from Shinshu University, Toshihiro Nakanishi from Kyoto University, Yosuke Nakata from Osaka University, and Joel Pérez-Urquizo, Julien Madéo, and Keshav M. Dani from Okinawa Institute of Science and Technology.

The proposed strategy is based on the frequency conversions that occur in time-varying systems. Much like a waveguide confines a traveling wave packet in space, there is an analogous concept that occurs in time known as temporal waveguiding. Simply put, variations that occur across an entire system over time will act as a "temporal boundary."

Similar to spatial boundaries (e.g., the interface between two different mediums), temporal boundaries can alter the dispersion properties of the waveguide, giving rise to different propagation modes at new frequencies.

To create this temporal boundary, the researchers first laid out a GaAs waveguide over a thin metallic layer. As terahertz waves traveled through the waveguide in the transverse magnetic (TM) mode, they shined a light on the bare GaAs surface. The resulting photoexcitation of the top surface instantaneously altered its conductivity, effectively turning the bottom-metalized waveguide into a parallel double-metalized waveguide.

This transition from one waveguide structure to another acted as the temporal boundary, at which the incident TM modes of the bare waveguide coupled with the transverse electromagnetic (TEM) mode of the double-metalized waveguide.

Given that the dispersion curve of the TEM mode occupies a lower frequency range than that of the incident TM mode, this approach produces a frequency-down-shifted terahertz wave.

The research team ran experiments that ultimately validated their thorough theoretical analysis of the proposed frequency conversion method. Thus, the findings of this study paint a bright future for upcoming terahertz technology.

Dr. Takano says, "Frequency conversion devices for terahertz waves have the potential to be applied to future ultra-high-speed wireless communications. For example, they could enable information replication between terahertz wave frequency channels carrying different data. There may also be devices where terahertz wave information processing circuits are integrated with various optical processing components."

Worth noting, up-conversion through the proposed approach was [also demonstrated](#) in a *Physical Review Letters* paper. Moreover, the up- and down-conversion can be switched by manipulating the polarization of the input terahertz waves, which would help make FDM in the terahertz range more convenient.

To top this off, the present frequency conversion method is not strictly limited to terahertz waveguides and could also have important implications in optics.

"It is important to recognize that the concept of this study extends beyond the terahertz frequency range and can be applied to the optical frequency range as well. Ultrafast frequency conversion devices comprising optically modulated waveguides with indium tin oxide may also be possible, based on recent findings," said Dr. Takano.

Further developments in this field could ultimately lead to faster and more energy-efficient telecommunications, helping us build a more interconnected and sustainable society.

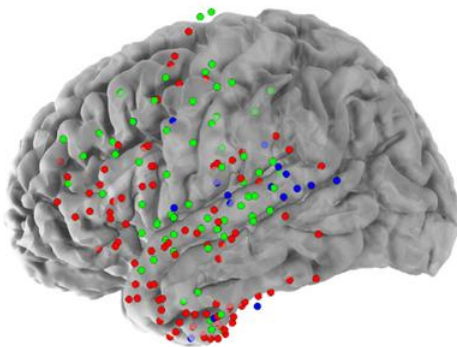
More information: Keisuke Takano et al, Frequency down-conversion of terahertz waves at optically induced temporal boundaries in GaAs waveguides, *Nanophotonics* (2024). DOI: [10.1515/nanoph-2024-0010](https://doi.org/10.1515/nanoph-2024-0010)

Scientists find neurons that process language on different timescales

In language-processing areas of the brain, some cell populations respond to one word, while others respond to strings of words.

Anne Trafton | MIT News

Publication Date:
August 26, 2024



By comparing their data with predictions made by a computational model that the researchers designed to process stimuli with different temporal windows, the researchers found that neural populations from language processing areas could be divided into three clusters. These clusters represent temporal windows of either one, four, or six words.

Caption:

This schematic shows a brain with implanted electrodes that are colored due to the "cluster" they belong to. Blue is one word, red is four, and green is six words.

Credits:

Image: Courtesy of the researchers; MIT News

[Previous image](#) [Next image](#)

Using functional magnetic resonance imaging (fMRI), neuroscientists have identified several regions of the brain that are responsible for processing language. However, discovering the specific functions of neurons in those regions has proven difficult because fMRI, which measures changes in blood flow, doesn't have high enough resolution to reveal what small populations of neurons are doing.

Now, using a more precise technique that involves recording electrical activity directly from the brain, MIT neuroscientists have identified different clusters of neurons that appear to process different amounts of linguistic context. These “temporal windows” range from just one word up to about six words.

The temporal windows may reflect different functions for each population, the researchers say. Populations with shorter windows may analyze the meanings of individual words, while those with longer windows may interpret more complex meanings created when words are strung together.

“This is the first time we see clear heterogeneity within the language network,” says Evelina Fedorenko, an associate professor of neuroscience at MIT. “Across dozens of fMRI experiments, these brain areas all seem to do the same thing, but it’s a large, distributed network, so there’s got to be some structure there. This is the first clear demonstration that there is structure, but the different neural populations are spatially interleaved so we can’t see these distinctions with fMRI.”

Fedorenko, who is also a member of MIT’s McGovern Institute for Brain Research, is the senior author of the study, which [appears today in *Nature Human Behavior*](#). MIT postdoc Tamar Regev and Harvard University graduate student Colton Casto are the lead authors of the paper.

Temporal windows

Functional MRI, which has helped scientists learn a great deal about the roles of different parts of the brain, works by measuring changes in blood flow in the brain. These measurements act as a proxy of neural activity during a particular task. However, each “voxel,” or three-dimensional chunk, of an

fMRI image represents hundreds of thousands to millions of neurons and sums up activity across about two seconds, so it can't reveal fine-grained detail about what those neurons are doing.

One way to get more detailed information about neural function is to record electrical activity using electrodes implanted in the brain. These data are hard to come by because this procedure is done only in patients who are already undergoing surgery for a neurological condition such as severe epilepsy.

“It can take a few years to get enough data for a task because these patients are relatively rare, and in a given patient electrodes are implanted in idiosyncratic locations based on clinical needs, so it takes a while to assemble a dataset with sufficient coverage of some target part of the cortex. But these data, of course, are the best kind of data we can get from human brains: You know exactly where you are spatially and you have very fine-grained temporal information,” Fedorenko says.

In a 2016 study, Fedorenko reported using this approach to study the language processing regions of six people. Electrical activity was recorded while the participants read four different types of language stimuli: complete sentences, lists of words, lists of non-words, and “jabberwocky” sentences — sentences that have grammatical structure but are made of nonsense words.

Those data showed that in some neural populations in language processing regions, activity would gradually build up over a period of several words, when the participants were reading sentences. However, this did not happen when they read lists of words, lists of nonwords, of Jabberwocky sentences.

In the new study, Regev and Casto went back to those data and analyzed the temporal response profiles in greater detail. In their original dataset, they had

recordings of electrical activity from 177 language-responsive electrodes across the six patients. Conservative estimates suggest that each electrode represents an average of activity from about 200,000 neurons. They also obtained new data from a second set of 16 patients, which included recordings from another 362 language-responsive electrodes.

When the researchers analyzed these data, they found that in some of the neural populations, activity would fluctuate up and down with each word. In others, however, activity would build up over multiple words before falling again, and yet others would show a steady buildup of neural activity over longer spans of words.

By comparing their data with predictions made by a computational model that the researchers designed to process stimuli with different temporal windows, the researchers found that neural populations from language processing areas could be divided into three clusters. These clusters represent temporal windows of either one, four, or six words.

“It really looks like these neural populations integrate information across different timescales along the sentence,” Regev says.

Processing words and meaning

These differences in temporal window size would have been impossible to see using fMRI, the researchers say.

“At the resolution of fMRI, we don’t see much heterogeneity within language-responsive regions. If you localize in individual participants the voxels in their brain that are most responsive to language, you find that their

responses to sentences, word lists, jabberwocky sentences and non-word lists are highly similar,” Casto says.

The researchers were also able to determine the anatomical locations where these clusters were found. Neural populations with the shortest temporal window were found predominantly in the posterior temporal lobe, though some were also found in the frontal or anterior temporal lobes. Neural populations from the two other clusters, with longer temporal windows, were spread more evenly throughout the temporal and frontal lobes.

Fedorenko’s lab now plans to study whether these timescales correspond to different functions. One possibility is that the shortest timescale populations may be processing the meanings of a single word, while those with longer timescales interpret the meanings represented by multiple words.

“We already know that in the language network, there is sensitivity to how words go together and to the meanings of individual words,” Regev says. “So that could potentially map to what we’re finding, where the longest timescale is sensitive to things like syntax or relationships between words, and maybe the shortest timescale is more sensitive to features of single words or parts of them.”

The research was funded by the Zuckerman-CHE STEM Leadership Program, the Poitras Center for Psychiatric Disorders Research, the Kempner Institute for the Study of Natural and Artificial Intelligence at Harvard University, the U.S. National Institutes of Health, an American Epilepsy Society Research and Training Fellowship, the McDonnell Center for Systems Neuroscience, Fondazione Neurone, the McGovern Institute, MIT’s Department of Brain and Cognitive Sciences, and the Simons Center for the Social Brain.

Elon Musk [recently pronounced](#) that the next Neuralink project will be a

"Blindsight" cortical implant to restore vision: "Resolution will be low at first, like early Nintendo graphics, but ultimately may exceed normal human vision."

Unfortunately, this claim rests on the [fallacy that neurons in the brain are like pixels on a screen](#). It's not surprising that engineers often assume that "more pixels equals better vision." After all, that is how monitors and phone screens work.

In our newly published research, we created a [computational model of human vision](#) to simulate what sort of vision an extremely high-resolution cortical implant might provide. A movie of a cat with a resolution of 45,000 pixels is sharp and clear. A movie generated using a simplified version of a model of 45,000 cortical electrodes, each of which stimulates a single neuron, still has a recognizable cat but most of the details of the scene are lost.

The reason why the movie generated by electrodes is so blurry is because neurons in the human visual cortex do not represent tiny dots or pixels. Instead, each neuron has a particular [receptive field](#), which is the location and pattern a visual stimulus must have in order to make that neuron fire. Electrically stimulating a single neuron produces a blob whose appearance is determined by that neuron's receptive field. The tiniest electrode—one that stimulates a single neuron—will produce a blob that is roughly the size of your pinkie's width held at arm's length.

Consider what happens when you look at a single star in the night sky. Each point in space is represented by many thousands of neurons with overlapping receptive fields. A tiny spot of light, such as a star, results in a complex pattern of firing across all these neurons.

To generate the visual experience of seeing a single star with cortical stimulation, you would need to reproduce a pattern of neural responses that is similar to the pattern that would be produced by natural vision.

In order to do this, you would obviously need thousands of electrodes. But you would also need to replicate the correct pattern of neuronal responses, which

requires knowing every neuron's receptive field. Our simulations show that knowing the location of each neuron's receptive field in space is not enough—if you don't also know the orientation and size of each receptive field, then the star becomes a fuzzy mess.

So, even a single star—a single, bright pixel—generates an immensely complex neural response in the visual cortex. Imagine the even more complex pattern of cortical stimulation needed to accurately reproduce natural vision.

Some scientists have suggested that by stimulating exactly the [right combination of electrodes](#), it would be possible to [produce natural vision](#). Unfortunately, no one has yet suggested a sensible way to determine the receptive field of each individual neuron in a specific blind patient. Without that information, there is no way to see the stars. Vision from cortical implants will remain grainy and imperfect, regardless of the number of electrodes.

Sight restoration is not simply an engineering problem. Predicting what kind of vision a device will provide requires knowing how the [technology interfaces with the complexities of the human brain](#).

How we created our virtual patients

In our work as [computational neuroscientists](#), we develop simulations that predict the perceptual experience of patients seeking to restore their sight.

We have previously created a model to predict the [perceptual experience of patients with a retinal implant](#). To create a virtual patient to predict what cortical implant patients would see, we simulated the neurophysiological architecture of the area of the brain involved in the [first stage of visual processing](#). Our model approximates how receptive fields increase in size from central to peripheral vision and the fact that every neuron has a unique receptive field.

[Our model successfully predicted](#) data describing the perceptual experience of participants across a wide range of studies on cortical stimulation in people. Having confirmed that our model could predict existing data, we used it to make predictions about the quality of vision that possible future cortical implants might produce.

Models like ours are an example of [virtual prototyping](#), which involves using computer systems to improve product design. These models can facilitate new technology development and evaluate device performance. Our study shows they can also offer more realistic expectations about what kind of vision bionic eyes might provide.

First do no harm

In our almost 20 years researching bionic eyes, we've seen the complexity of the human brain defeat company after company. [Patients pay the cost](#) when these devices fail, left stranded with orphaned technologies in their eye or brain.

The Food and Drug Administration could mandate that sight recovery tech companies must develop [failure plans that minimize harm](#) to patients when technologies stop working. Possibilities include requiring companies implanting neuroelectronic devices into patients to participate in [technology escrow agreements](#) and carry insurance to ensure continuing [medical care](#) and [technology support](#) if they go bankrupt.

If cortical implants can achieve anything close to the resolution of our simulations, that would still be an accomplishment worth celebrating. Grainy and imperfect vision would be life-changing for many thousands of people who currently suffer from incurable blindness. But this is a moment for cautious rather than blind optimism.

How can the brain continue to learn without overloading our memory?

Article author: Cédric DEPOND

Source: [Science](#)

A recent study from Cornell University reveals that sleep not only consolidates memory but also resets neurons, allowing the brain to keep learning without depleting its resources. This discovery could have major implications for treating neurological disorders such as Alzheimer's disease or post-traumatic stress disorder.

When a person learns or experiences new things, neurons in the hippocampus, a key brain region for memory, become active. During sleep, these neurons replay the activity patterns observed during the day, a process essential for memory consolidation, with memories then stored in the cortex. However, scientists have questioned how the brain can continue acquiring new information throughout life without exhausting its neurons.

The study, published in *Science*, shows that at certain moments during deep sleep, specific regions of the hippocampus "shut down," allowing neurons to reset. Azahara Oliva, assistant professor of neurobiology and lead author of the study, explains: "This mechanism might allow the brain to reuse the same neurons for new learning the next day."

The hippocampus is divided into three main regions: CA1, CA2, and CA3. The CA1 and CA3 regions, well-studied, are involved in encoding time-and-space-related memories. In contrast, the function of CA2 was less understood until now. This research demonstrated that CA2 is essential in causing the silencing of other hippocampal regions, thus facilitating memory "reset" during sleep.

Researchers implanted electrodes in the hippocampus of mice to record neural activity during learning and sleep. They observed that neurons in the CA1 and CA3 regions replay neural patterns developed during the day before being silenced by the influence of CA2. This suggests the brain has parallel circuits regulated by two types of neurons: pyramidal neurons, crucial for learning, and interneurons, which ensure memory resetting.

This discovery is pivotal in understanding why sleep is essential in all animals: it not only serves to consolidate memories but also to reset the brain for continued functionality during waking hours. Researchers hope this knowledge can be used to enhance memory and treat related disorders, like Alzheimer's, or to erase traumatic memories.



Various changes are seen in the brains of people with Alzheimer's, but the exact cause of the disease is unclear
Science Photo Library/Alamy© Provided by New Scientist

A new understanding of Alzheimer's disease suggests that the root cause involves a build-up of fat droplets in brain cells.

Targeting these droplets could lead to more effective treatments than the current strategy of drugs that target proteins, says [Michael Haney](#) at the University of Pennsylvania. "This opens up a new avenue for therapeutic development," he says.

We may finally know how cognitive reserve protects against Alzheimer's

The commonest explanation for Alzheimer's disease is that it is caused by a build-up of a protein called [beta-amyloid in plaques between nerve cells](#). Another suspect is a build-up of tangles made of a different protein, called tau, stored inside nerve cells.

Arguments over which of these two proteins is the key culprit have gone on for decades. The amyloid hypothesis is currently in the lead, as some [antibody treatments](#) that rid the brain of it have recently shown modest effectiveness at slowing memory loss in people with Alzheimer's.

But this debate ignores the fact that fat droplets can also be seen in the brains of people who have died from the disease, says Haney. These were first described by Alois Alzheimer, a German doctor who gave his name to the condition in the

early 20th century, when he noted amyloid plaques, tau tangles and fat droplets present in the brains of people who had Alzheimer's. But for decades the fat was mostly overlooked.

In the latest study, Haney was investigating the biggest genetic risk factor for Alzheimer's disease: a gene called *APOE*. The protein it encodes helps transport fat into and out of cells.

People have different variants of this gene, called *APOE2*, *3* and *4*. Of these, *APOE2* brings the least risk of developing Alzheimer's, while *APOE4* brings the most – although until now, it wasn't clear why.

To shed more light, Haney and his colleagues carried out a series of experiments while he was working at Stanford University in California. First, the team used a relatively recent technique called single-cell RNA sequencing to identify which proteins were being made in individual cells. They applied this to tissue samples from people who had died from Alzheimer's disease, who had either two copies of the *APOE4* variant or two copies of *APOE3*.

This showed that the key difference in the people with *APOE4* is that immune cells in their brain had higher levels of a certain enzyme, the effect of which was to boost fat droplets in those cells.

In a further experiment, the team grew this kind of brain immune cell – called microglia – in a dish, using cells from living people with either the *APOE4* or *APOE3* variant. Applying amyloid to the cells made them accumulate fat, especially if they had the *APOE4* variant.

The team concluded that in Alzheimer's, a build-up of amyloid triggers fat accumulation. This then leads to the build-up of tau inside neurons, which causes cell death, and so leads to the symptoms of memory loss and confusion.

Previous studies have found that other genes that raise Alzheimer's risk, but to a lesser extent than *APOE4*, tend to be involved in [fat metabolism or the immune system](#), which further supports their hypothesis, says Haney.

How to keep your brain healthy: The 7 things you should do every day

[Irundika Dias](#) at Aston University in Birmingham, UK, who wasn't involved in the work, says previous studies have suggested fat metabolism in other kinds of brain

cells could also be playing a role. "The common thing tying all these [findings] is involvement of lipid [fat] metabolism," she says. "But this is a very interesting paper."

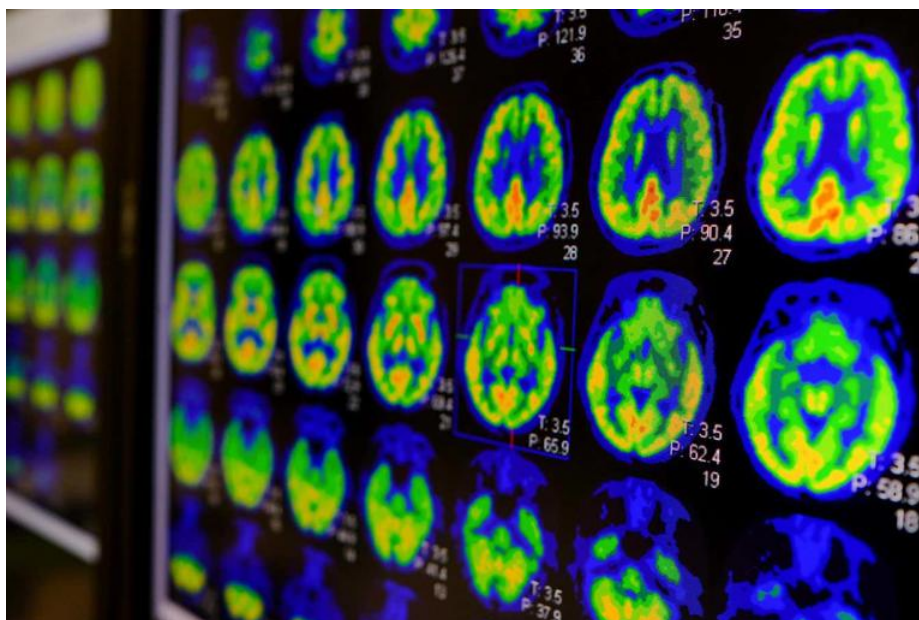
The finding comes as separate research suggests harmful *APOE* gene variants are behind more than three-quarters of Alzheimer's cases. That work, by [Dylan Williams](#) at University College London and his colleagues, was based on a population study called UK Biobank, which recorded the *APOE* variant people had and tracked their health records.

Compared with people who have two copies of the least-risk variant, *APOE2*, those with either one or two copies of the other variants were nearly four times more likely to get Alzheimer's disease, they reported in a [paper posted online](#).

This means that about 75 per cent of people who get Alzheimer's wouldn't do so if we could somehow intervene in this molecular pathway, says Williams. "Given that we're in a rare position where differences in this one protein seem to be responsible for a large majority of the disease burden, if we design drugs where we could somehow mitigate that risk, we would expect to prevent most disease."

Journal reference

Nature Medicine DOI: [10.1038/s41586-024-07185-7](https://doi.org/10.1038/s41586-024-07185-7)



PET scans of a human brain Utthapon wiratepsupon/Shutterstock© Provided by New Scientist

Researchers have drawn up the most detailed description ever created of the human brain, based on the thousands of different cell types that make it up.

The human brain cell atlas is a series of data sets about the various cell types within the brain and where they are located, defining this complex organ in more precise genetic and molecular detail than ever before.

The data comes from samples taken from deceased adults and children and from embryos and fetuses during pregnancy. The donors include some individuals who have certain medical conditions and others who don't.

Samples from chimpanzees, gorillas and monkeys have also been included in order to shed light on brain evolution.

The resource has been compared to the enormous effort that went into the [Human Genome Project](#), which led to multiple medical advances.

It is designed to lay the groundwork for further research into conditions that affect the brain, including neurological conditions such as Alzheimer's and Parkinson's disease, as well as mental health problems such as depression and schizophrenia. "If you're going to explore a new country, you need a map so you know where you're going," says [Sten Linnarsson](#) at the Karolinska Institute in Stockholm, Sweden.

Previous attempts to visualise the brain have involved scanning techniques such as magnetic resonance imaging (MRI). While brain scanning can be invaluable for making medical diagnoses of individuals – for instance, by revealing a brain tumour – they typically can't visualise anything smaller than about 1 millimetre.

The new atlas allows us to analyse the brain at a much smaller scale by identifying cell types taken from more than 100 different regions of the brain, depending on the species and age of the donors.

It was already known that there are many different types of brain cells, or neurons, partly based on the fact that they can look different or behave differently when grown in a dish. For instance, while most neurons send signals that trigger the next neuron down the line to fire, some send signals that stop the next neuron from firing.

But it was difficult to precisely identify the multitude of different neurons that exist until the advent of a technique called [single-cell sequencing](#) about 20 years ago.

This analyses the genetic material of a single cell to see which genes are turned on or off – in other words, which proteins it is making.

As single-cell sequencing techniques progressed, the US National Institutes of Health began funding two initiatives, which coalesced into a set of 24 papers published on 12 October.

The first aimed to draw up a brain cell “census”, consisting of a detailed description of all the different cell types in the human brain, based on which of their genes are active. The second set out to identify exactly where in the brain those types of neuron are found in order to produce a cell-based atlas of the brain – although, at the moment, it exists only as a huge set of databases, rather than a single visual representation.

The first draft involved efforts by multiple international research teams, sequencing millions of brain cells altogether.

Updated brain map reveals how we control the movement of our bodies

Linnarsson was involved in several of the projects, including carrying out single-cell sequencing of 105 anatomical locations from four adult brains. The project identified 3313 different types of brain cells.

Some insights into different medical conditions are already starting to emerge. “There are papers [due to come out] from geneticists that are mapping all the disease genes of brain diseases to our atlas,” says Linnarsson. “There will be insights there for sure.”

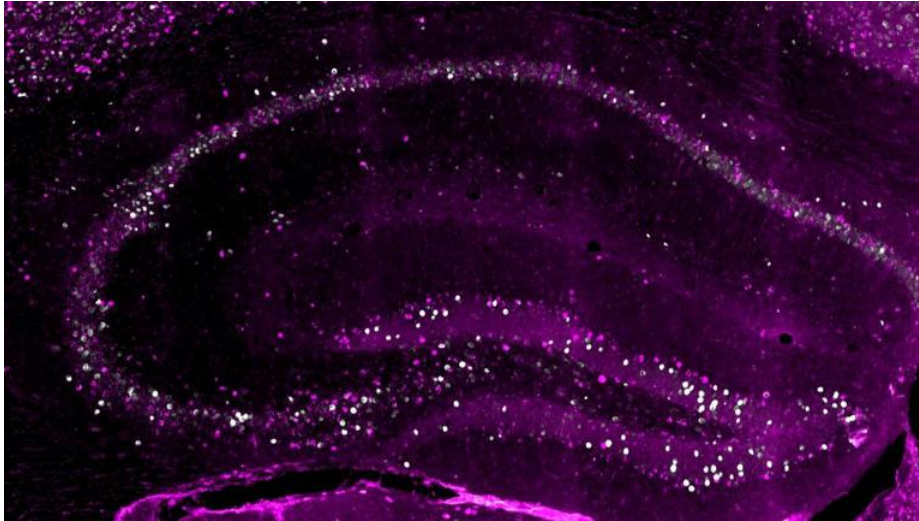
“There’s an enormous incentive for understanding brain function, not just because it’s such an intriguing question, but also because it can lead to therapies,” says [Arnold Kriegstein](#) at the University of California, San Francisco, who is part of the team drawing up atlases for the fetal brain at different stages of development.

“In future, researchers may be able to use these tools to study cell-specific and circuit-specific activity which underlies complex cognition and behaviour,”

says [Barbara Sahakian](#) at the University of Cambridge, who wasn't involved in the research. "This will not only advance our knowledge of the healthy brain, but may also lead to novel treatments for brain disorders."

Journal reference:

Science DOI: [10.1126/science.add7046](https://doi.org/10.1126/science.add7046)



Swirls of fluorescent magenta are shown against a black background. There are also spots of white dotted along the swirls. © Biozentrum, University of Basel

Memories evolve [throughout our lifetimes](#), changing as we learn and experience new things and as we recall a memory repeatedly. And then, memories degrade as we age.

Previously, scientists thought that this malleability was the result of changes in the brain cells that originally encoded the memory, and they believed these cells stored [just one copy of every memory](#) in the brain. However, new research suggests that might not be true.

The scientists found that, in rodents, the brain stores at least three copies of a given memory, encoding it in multiple places in the organ.

These copies are encoded by different groups of neurons in the [hippocampus](#), a brain region critical for learning and memory. The copies vary in terms of when they're created, how long they last and how modifiable they are through time.

In the new study, published Aug. 16 in the journal [Science](#), the scientists showed that, as mice encode new memories, they first create so-called early-born neurons. These neurons are responsible for storing a long-term copy of the memory that is initially weak but becomes stronger over time.

Next comes middle-ground neurons, which are more stable from the outset, followed by late-born neurons that from the beginning encode very strong copies of a memory. However, that strength fades over time.

Researchers uncovered these findings by examining the activity of different groups of neurons in the hippocampus after mice had completed various memory tasks. These tasks involved learning to avoid harmful situations, such as receiving an electric shock to their feet, before being confronted with the same task later on.

The way these three groups of neurons operate on different timescales may help explain how the brain regulates memories over time, the study authors suggested. However, it is still unclear how exactly these neurons interact with each other to facilitate this, study co-author [Flavio Donato](#), an assistant professor of neurobiology at the University of Basel in Switzerland, told Live Science.

Notably, the memories stored by late-born neurons were more plastic, or malleable, than those of early-born neurons, the team found. This suggests that at the start of memory formation — when early-born neurons reign — the information stored remains fairly stable over time, while memories stored later on are more easily warped by new information.

If the same phenomenon happens in humans, this finding could someday lead to the development of new therapies for specific disorders, Donato said. For example, in post-traumatic stress disorder (PTSD), people experience intrusive memories, meaning unwanted, distressing memories of a traumatic event. Perhaps a drug could be designed that preferentially activates late-born neurons, which are more plastic and thus more receptive to psychotherapy, he said.

In the case of people with memory loss due to dementia, meanwhile, another type of drug could stimulate the activity of early-born neurons, whose data is stored more rigidly. Broadly speaking, such treatments would manipulate the properties of a memory by selecting which type of neuron is used to encode it in the brain, Donato explained.

"I feel like we now have biological entry points to modulate the plasticity of memory in a way that might allow us to push it towards being more or less plastic, in order to preserve it or to basically re-write it," Donato said.



Old people can produce as many new brain cells as teenagers© Organically Human

Research contradicts decades-old theory that humans stop producing neurons in adulthood

Elderly people grow as many new brain cells as teenagers, according to a new study which counters previous theories that neurons stop developing after adolescence.

Healthy men and women continue to produce new neurons throughout life, suggesting older people remain more cognitively and emotionally intact than previously believed, researchers found.

For decades it was thought that adult brains were hard-wired and unable to form new cells.

But a Columbia University study found older people continued to produce neurons in the hippocampus – a part of the brain important for memory, emotion and cognition – at a similar rate to young people.

Researchers examined the brains of 28 previously healthy people who died suddenly between the age of 14 and 79.

"We found that older people have similar ability to make thousands of hippocampal new neurons from progenitor cells as younger people do," said the study's lead author Maura Boldrini, associate professor of neurobiology.

"We also found equivalent volumes of the hippocampus across ages."

The ability to generate new hippocampal cells, a process known as neurogenesis, declines with age in rodents and primates.

Declining production of neurons and shrinkage of parts of the brain which help form of new episodic memories were believed to occur in ageing humans as well, explaining why younger people find it easier to learn skills and languages.

But the Columbia University study found similar numbers of newly formed cells in old and young brains.

However, the researchers also noted fewer blood vessels and connections between cells in the older brains, which Ms Boldrini said "may be linked to compromised cognitive-emotional resilience" in the elderly.

The findings, published in the journal *Cell Stem Cell*, are likely to be hotly debated.

They come just a month after a University of California study suggested adults do not develop new neurons.

Shawn Sorrells and Mercedes Paredes, who co-authored that research, said: "For now, we do not think this new study challenges what we have concluded from our own recently published observations: if neurogenesis continues in the adult human hippocampus, it is an extremely rare phenomenon."

However, other scientists said the Columbia University findings were promising and could be helpful in developing new treatments for neurological conditions such as Alzheimer's Disease..

The post [Old people can produce as many new brain cells as teenagers](#) appeared first on [Organically Human](#).



Scientists find a way to regenerate old neurons

Imagine a brain, the soft tissue inside your head, that is injured and can't heal.

This is the harsh reality for millions worldwide dealing with neurological disorders like trauma, stroke, epilepsy, and neurodegenerative diseases. The inability to regenerate neurons worsens these conditions.

The devastation results from the permanent loss of neurons. These cells are crucial for our brain and nervous system.

When neurons are lost, it can lead to serious issues in how our brain functions. Sadly, this loss significantly impacts our abilities and daily life. Now imagine a world where we can regrow these neurons!

This is the promising horizon of research carried out by two teams of scientists led by Magdalena Götz, chair of physiological genomics at Ludwig Maximilian University of Munich ([LMU](#)), head of the Stem Cell Center Department at Helmholtz Munich.

Regenerating neurons

At the heart of their research is a sophisticated process called direct neuronal reprogramming, wherein the function of one cell is changed into another.

In essence, within the brain, non-neuronal cells, known as glial cells, are converted into functional neurons.

This process holds great potential for treating neurological disorders, though it presents its own complexities and challenges. These factors spark excitement among neuroscientists and researchers in regenerative medicine, who are eager to overcome these hurdles and enhance our understanding and treatment options.

The research, published in the journal *Nature Neuroscience*, dives into the molecular mechanisms that come into play during the conversion of glial cells into neurons. The researchers brought into focus the small chemical modifications that occur in the epigenome during this process.

Unlocking the epigenetic puzzle

The epigenome is the complex biological system that choreographs which genes are active in different cells at different times. For the first time, Götz, Bonev and their teams have managed to demonstrate how this intricate pattern of the epigenome is directed by a single transcription factor.

During this feat of biological engineering, they employed novel epigenome profiling methods and managed to make a breakthrough discovery: the transcriptional regulator YingYang1.

A gamechanger in regenerating neurons

Much like the symbol it's named after, YingYang1 brings balance to the process of converting astrocytes to neurons.

But how does it do it? Well, it opens up the chromatin for reprogramming and interacts with the transcription factor to drive the transformation of the cell.

This discovery is a leap forward in understanding [cell reprogramming](#) and brings us tantalizingly closer to therapeutic solutions for a number of devastating neurological disorders.

The road ahead

The discovery of YingYang1 is a significant breakthrough. It helps us understand how neurons can regenerate. This finding could lead to new treatments for different neurological conditions. Overall, it opens up exciting possibilities for the future of brain health.

While the findings from Götz and Bonev's teams spark enthusiasm within the scientific community, a number of challenges remain on the path to clinical application.

Further research is essential to understand the comprehensive effects of manipulating the epigenome and to ensure the safety and efficacy of potential treatments.

Additionally, establishing methods for targeted delivery of therapies to specific neuronal types will be critical in achieving successful outcomes.

Nevertheless, the promise of neuronal regeneration through direct reprogramming invites a renewed sense of hope for those affected by neurological disorders, as scientists work tirelessly to translate these [discoveries into viable treatments](#).

A promise for tomorrow

"The protein YingYang1 is crucial for achieving the conversion from astrocytes to neurons," explains Götz. "These findings are important to understand and improve reprogramming of glial cells to neurons, and thus bring us closer to therapeutic solutions."

This breakthrough research reminds us of the power of human curiosity and determination. It highlights that even in the face of daunting complexities, we can decipher intricate mechanisms of life and harness them to improve human health.

While the pathway to an effective and reliable treatment for neuronal loss is long, each discovery like this marks a critical stepping-stone in our journey. The research opens up entirely new possibilities and enlightening insights into ways we might regenerate the neurons necessary for human beings to live healthy, fulfilling lives.

Today, regeneration of neurons might still be confined largely to the world of research, but tomorrow, it could be a reality that transforms millions of lives.

The study is published in the journal [Nature Neuroscience](#).

In recent years, more adults between the ages of 45 and 64 have been dying from strokes, according to [a new report](#) from the Centers for Disease Control and Prevention (CDC). [Stroke](#) occurs when blood flow to the brain is blocked or there's sudden bleeding in the brain. Unless treated quickly, it can lead to lasting brain damage, long-term disability or death.

After declining from 2002 to 2012, stroke death rates for middle-aged adults increased 7% between 2012 and 2019, and increased an additional 12% through 2021, the CDC found. The stroke death rate then fell slightly (by 2%) for men through 2022, and "did not change significantly" for women.

The CDC report didn't explore possible reasons for the spike in stroke deaths. However, experts tell Yahoo Life there could be a few explanations.

Reason #1: An increase in stroke risk factors — especially high blood pressure

Underlying conditions like diabetes, obesity and [hyperlipidemia](#) (aka high cholesterol) have increased among middle-aged adults, as have poor lifestyle habits such as alcohol use, unhealthy diets and physical inactivity — all of which are typical risk factors for stroke, experts say.

"These risk factors over time lead to [atherosclerosis](#), which is a common cause of stroke in older patients. However, we have seen an increase in these same risk factors leading to stroke in our younger patient population," [Dr. Fan Caprio](#), a vascular neurologist at Northwestern Medicine and medical director for its Comprehensive Stroke Center, tells Yahoo Life.

An increase in risk factors, Caprio explains, can lead to more and bigger strokes — which in turn can lead to higher mortality and morbidity.

One of the most notable risk factors behind the rise is [hypertension](#), or high blood pressure.

"Hypertension, which is the most important stroke risk factor, has increased among middle-aged adults," Adam Vaughan, an epidemiologist with the CDC's Division for Heart Disease and Stroke Prevention, tells Yahoo Life. Vaughan adds that more than half of middle-aged adults with hypertension have "[uncontrolled hypertension](#)" — meaning their high blood pressure is untreated or not responding to treatment.

[Dr. Mona Bahouth](#), medical director of the Brain Rescue Unit at Johns Hopkins Medicine, adds that what can make high blood pressure so dangerous is the fact that it's "fairly silent."

"You don't really feel that you have high blood pressure until you've had it for a while and it's too late, unless you're measuring it," she tells Yahoo Life.

Reason #2: Missing doctor appointments

Vaughan points out that socioeconomic disparities could also be at play. "Many people in this age group might have [limited access to health care](#), leading to undiagnosed or not controlled risk factors, and delayed treatment in general," he says.

It's also possible that COVID-19 may have contributed to the rise. Rates in stroke deaths spiked 12% during the early years of the pandemic, which could be because more people missed doctor appointments and preventive screenings that would have identified some of those crucial risk factors. Still, Bahouth says we "can't really take that bait too easily"; although stroke deaths increased early in the pandemic, the study shows that rates were already on the rise before COVID came into the picture.

Reason #3: Not recognizing stroke symptoms

Stroke can be mistakenly viewed as a "disorder of the elderly." As such, when a middle-aged person starts to develop symptoms of a stroke, those symptoms might be dismissed and medical attention delayed until it's too late, Caprio says.

Experts say it's imperative that people of all ages recognize the telltale signs of stroke, which include:

- sudden weakness or dizziness
- sudden numbness, especially on one side of the body
- sudden trouble speaking or understanding speech
- sudden severe headache

If you notice these symptoms, call 911 immediately. Fast treatment can not only be lifesaving but also lessen the likelihood of brain damage brought on by stroke and prevent another stroke from occurring.

Miniscule magnetic nanobots that can travel deep inside the brain to repair deadly aneurysms have been created by the University of Edinburgh. The sphere-shaped [nanobots](#), which are about a 20th of the size of a human red blood cell, are made from iron oxide, which becomes magnetic when placed in an external magnetic field.

They also carry thrombin, an enzyme crucial in blood clotting and inflammation.

Brain aneurysms are a bulge or ballooning in the weakened area of a [blood vessel](#) that can burst and cause dangerous bleeding if not stopped quickly.

In laboratory tests, several hundred billion nanobots were injected into an artery and the swarm was directed remotely to the site of an aneurysm using magnets and real-time ultrasound scans.

Once there, the nanobots clustered together inside the aneurysm and heated to more than 109F (43C) using an alternating magnetic field to melt their protective coating and release the clotting drug to the precise location.

Scans showed that after the clotting had happened, the aneurysm vanished, leaving a healthy blood vessel.

Dr Qi Zhou, of the University of Edinburgh's School of Engineering, who co-led the study, said: "Nanorobots are set to open new frontiers in medicine – potentially allowing us to carry out surgical repairs with fewer risks than conventional treatments and target drugs with pinpoint accuracy in hard-to-reach parts of the body.

Are brain implants the future of computing?

“Our study is an important step towards bringing these technologies closer to treating critical medical conditions in a clinical setting.”

In Britain, about 2 to 3 per cent of people will develop a brain aneurysm, which is caused by weaknesses in the walls of the blood vessels in the brain. About one in 15,000 people suffer a ruptured brain aneurysm in the UK each year.

If the aneurysm leaks or ruptures, it causes bleeding in the brain, known as a hemorrhagic stroke, which can be life-threatening and needs immediate treatment.

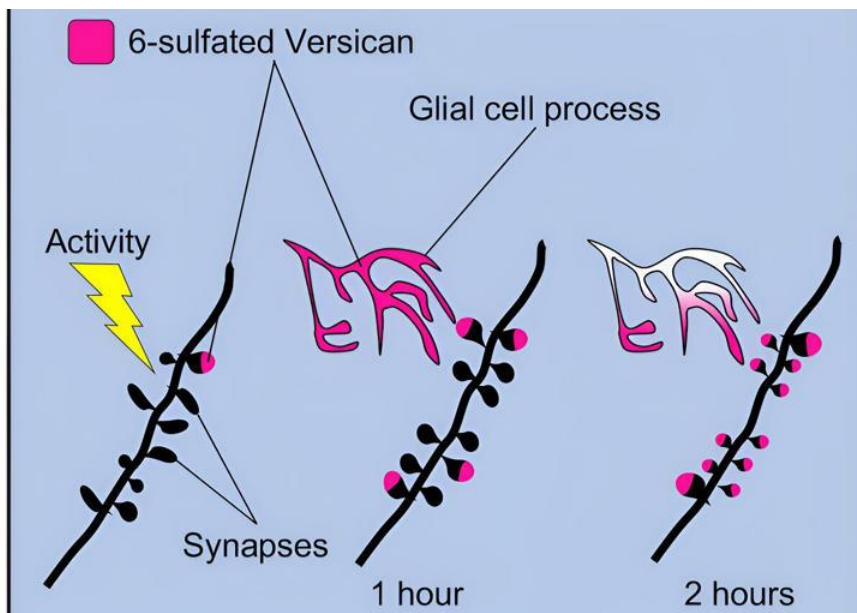
The condition is treated by threading a tube along blood vessels and inserting metal coils to stem the blood flow, or a mesh tube called a stent, to divert the bloodstream in the artery.

But the body can reject the implanted materials, and patients must be given anti-blood clotting drugs that can cause bleeding and stomach problems.

For the new trials, the team tested the nanobots on arteries in vitro and animals, but are hopeful that they could soon move to testing in humans.

Experts also believe that the nanobots could be used to repair organs and other blood vessels, as well as moving medicines to precise locations in the body.

The team, which worked alongside clinicians from Shanghai Sixth People’s Hospital, have also developed nanorobots to remove blood clots, which could one day be used to treat [stroke patients](#).



Graphical abstract. Credit: Cell Reports (2024). DOI: 10.1016/j.celrep.2024.114112© Provided by Medical Xpress

Neurons are important, but they are not everything. Indeed, it is "cartilage," in the form of clusters of extracellular matrix molecules called chondroitin sulfates, located in the outside nerve cells, that plays a crucial role in the brain's ability to acquire and store information.

A study published in *Cell Reports* [describes a new mechanism of brain plasticity](#), or how nerve connections change in response to external stimuli. The paper is titled "Focal clusters of peri-synaptic matrix contribute to activity-dependent plasticity and memory in mice."

The work stems from a collaboration between the Harvard Medical School, the University of Trento, and the German Center for Neurodegenerative Diseases (DZNE) in Magdeburg.

"Sensory skills and the ability to understand our surroundings depend on the activity of the brain, which enables us to perceive and process stimuli that come from the outside world. Through our brains we are able to acquire and store new information, and to remember information we have already acquired," say Yuri Bozzi and Gabriele Chelini.

"This fascinating phenomenon is made possible by the brain's ability to continuously change the structure and effectiveness of neuronal connections (synapses) in response to external stimuli. An ability that goes by the name of synaptic plasticity. Understanding how synaptic modifications occur and how they contribute to learning and memory is one of the great challenges in neuroscience."

Yuri Bozzi is a professor at the University of Trento and co-senior author. Gabriele Chelini is the first author of the study. Chelini worked on this project starting in 2017, as a postdoctoral fellow in a lab directed by Sabina Berretta (McLean Hospital and Harvard Medical School, Boston), and completed the scientific publication during his years as a postdoctoral fellow in Bozzi's lab at the University of Trento.

At the center of the research are chondroitin sulfates, molecules well known for their role in joints, which also play a crucial function in brain plasticity, being an integral part of the brain's extracellular matrix, as was originally discovered in 2001 by Dr. Alexander Dityatev's group.

In 2007, a Japanese study described the presence of clusters of chondroitin sulfates, circular in shape, scattered seemingly randomly in the brain. This work had slipped into oblivion, however, until Sabina Berretta's translational neuroscience laboratory brought these structures back to the attention of the scientific community, renaming them CS-6 clusters (from chondroitin sulfate-6, which identifies their precise molecular composition) and demonstrating how these structures were associated with glial cells and were severely reduced in the brains of people with psychotic disorders.

Then in 2017, Gabriele Chelini, newly hired in Berretta's lab, was tasked with revealing the function of these clusters.

"First we went to explore these structures in detail, visualizing them at very high resolution. We found that they are essentially clusters of synapses coated with CS-6 and organized in a clearly recognizable geometric shape. We then highlighted a new type of synaptic organization," the scholars recount.

"At this point, we had to use some 'experimental creativity'; with a combination of behavioral, molecular and refined morphological approaches, we realized that

these connections encapsulated in CS-6 clusters change in response to electrical activity in the brain."

"Finally, through collaboration with Alexander Dityatev at DZNE Magdeburg, and the efforts of Hadi Mirzapourdelavar from his group, we attenuated the expression of CS-6 in the hippocampus (the region of the brain responsible for spatial learning), and demonstrated that the presence of CS-6 is necessary for synaptic plasticity and spatial memory," Bozzi and Chelini point out.

"This work paves the way for a new way of thinking about brain functioning. It is possible that all synapses formed on different neurons within CS-6 clusters have the ability to respond chorally to specific environmental stimuli, and are involved in a common function aimed at learning and memory processes," they note.

"They seem to represent a new substrate of information integration and association formation at the multicellular level," add Dityatev and Berretta.

The work is the result of a collaboration between several laboratories, including the translational neuroscience laboratory (Sabina Berretta; McLean Hospital—Harvard Medical School, Boston), the neurodevelopmental disorders research laboratory (Yuri Bozzi; CIMEC—Centro Interdipartimentale Mente/Cervello, University of Trento) and the Molecular Neuroplasticity laboratory (Alexander Dityatev; DZNE Magdeburg).

More information: Gabriele Chelini et al, Focal clusters of peri-synaptic matrix contribute to activity-dependent plasticity and memory in mice, *Cell Reports* (2024). DOI: [10.1016/j.celrep.2024.114112](https://doi.org/10.1016/j.celrep.2024.114112)



Scientists make history by cracking the Autism code

A team of researchers from multiple universities, including the University of Virginia, has recently developed a system that identifies genetic markers of autism in brain images. The ingenious part? This system does so with an impressive accuracy between 89 and 95 percent.

The findings create ripples in the world of medicine. They signal a future where medical professionals can potentially identify, classify, and treat autism and related neurological conditions without waiting for behavioral cues.

The implications of such a development are profound. The research could ultimately facilitate earlier interventions, drastically altering the experiences of those affected by autism.

Autism and genetics

"Autism is traditionally diagnosed behaviorally but has a [strong genetic basis](#). A genetics-first approach could transform understanding and treatment of autism," the researchers noted in their paper.

The research was led by Gustavo K. Rohde, a professor at the [University of Virginia](#) who is an expert in biomedical and electrical and computer engineering,

Professor Rohde has collaborated with distinguished researchers from the University of California San Francisco ([UCSF](#)) and the Johns Hopkins University [School of Medicine](#). Among them is Shinjini Kundu, Rohde's former PhD student and first author of the paper.

Genetic variations linked to autism

Kundu, currently a physician at the Johns Hopkins Hospital, played a key role in shaping this initiative. In collaboration with Professor Rohde, Kundu developed an inventive computer modeling technique called Transport-Based Morphometry (TBM). This method sits at the heart of their approach, forming a critical piece of the puzzle.

InBloom Autism Services (3) - Loving Living Local

Unlike other machine learning image analysis models, TBM operates on the principle of mass transport. It refers to the movement of molecules such as proteins, nutrients, and gases in and out of cells and tissues. Essential to various biological processes, these movements fashion the physical forms that TBM seeks to measure and quantify.

What makes TBM special is its ability to reveal patterns in brain structure that predict variations in certain regions of an individual's [genetic code](#). This phenomenon, known as "copy number variations" (CNVs), refers to segments of the genetic code that are duplicated or deleted. It's these variations that are linked to autism.

Brain morphology and autism

A problem that researchers often encounter is distinguishing normal biological variations in brain structure from those associated with deletions or duplications.

This distinction is vital to understanding the link between CNVs and brain morphology - essentially, the arrangement of different types of brain tissues such as grey or white matter in our brain.

"Finding out how CNV relates to brain tissue morphology is an important first step in understanding autism's biological basis," explained Professor Rohde. TBM can successfully make that distinction, a feat that puts it leagues ahead of other machine learning methods.

More effective autism interventions

The clinical implications of this research extend beyond diagnostic capabilities. With a better understanding of the genetic underpinnings of autism through brain images, medical professionals could tailor interventions that are not only earlier but also more effective for each individual.

This personalized approach could involve targeted therapies designed to address specific genetic markers identified in a patient.

Moreover, as research continues to uncover the intricate relationships between genetics, brain morphology, and [behavioural manifestations](#), we may witness the emergence of holistic treatment frameworks that integrate genetic insights alongside traditional therapeutic modalities.

Broader implications of the research

The exploration of genetic markers in autism via advanced imaging techniques has broader implications for [mental health](#) research as a whole.

Findings from this study could serve as a blueprint for investigating other neurological and developmental conditions, potentially revealing shared biological mechanisms among them.

Such pathways could enhance our understanding of conditions like schizophrenia and attention deficit hyperactivity disorder (ADHD), thereby expanding the toolkit available to clinicians and researchers.

Ultimately, this research emphasizes the importance of interdisciplinary collaboration in unraveling the complexities of mental health, offering hope for a more nuanced understanding of the biological foundations that inform effective treatments in the future.

Unlocking the potential of brain imaging

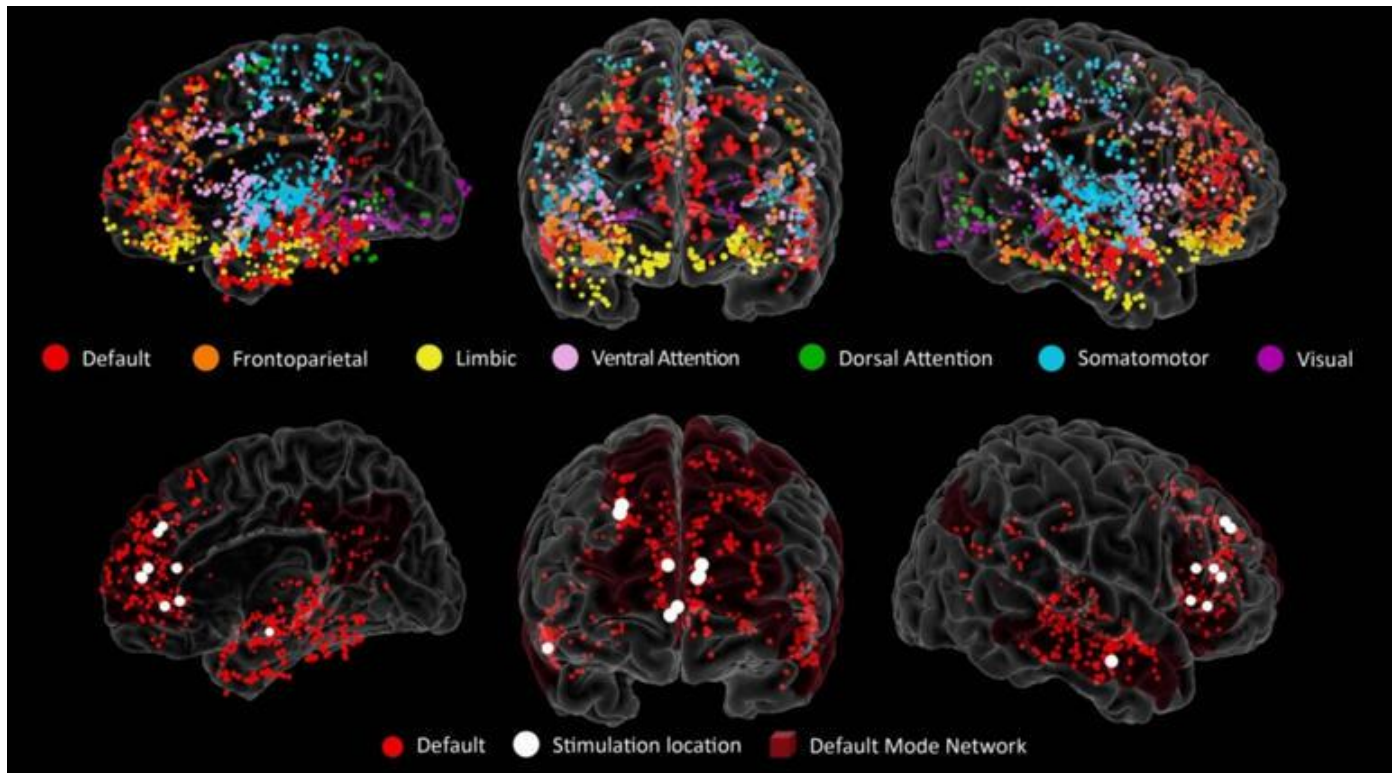
According to Forbes magazine, 90% of biomedical data exists in the form of imaging. Unfortunately, our current tools don't allow us to fully unlock the wealth of information contained within these images.

Professor Rohde believes that TBM is the key to tapping into this untapped repository of knowledge.

"As such, major discoveries from such vast amounts of data may lie ahead if we utilize more appropriate mathematical models to extract such information," said Professor Rohde.

"We hope that the findings, the ability to identify localized changes in brain morphology linked to copy number variations, could point to brain regions and eventually mechanisms that can be leveraged for therapies."

The study is published in the journal [Science Advances](#).



Electrodes at multiple brain regions reveal brain activity in real time. Colored dots show the locations of all of the electrodes across all patients, color-coded by brain region. Red dots in the lower images show the locations of the electrodes in the DMN. Credit: *Brain* (2024). DOI: 10.1093/brain/awae199© Provided by Medical Xpress

Have you ever had the solution for a tough problem suddenly hit you when you're thinking about something entirely different? Creative thought is a hallmark of humanity, but it's an ephemeral, almost paradoxical ability, striking unexpectedly when it's not sought out.

And the neurological source of creativity—what's going on in our brains when we think outside the box—is similarly elusive.

But now, a research team led by a University of Utah Health researcher and based in Baylor College of Medicine has used a precise method of brain imaging to unveil how different parts of the brain work together in order to produce creative thought.

[Their findings published](#) in *Brain* on June 18.

The new results could ultimately help lead to interventions that spark creative thought or aid people who have mental illnesses that disrupt these regions of the brain.

Outside the box

Higher cognitive processes like creativity are especially hard to study. "Unlike motor function or vision, they're not dependent on one specific location in the brain," says Ben Shofty, MD, Ph.D., assistant professor of neurosurgery in the Spencer Fox Eccles School of Medicine and senior author on the paper. "There's not a creativity cortex."

Exploring my creativity

But there's evidence that creativity is a distinct brain function. Localized brain injury caused by stroke can lead to changes in creative ability—both positive and negative. That discovery suggests that narrowing down the neurological basis of creativity is possible.

Shofty suspected that creative thought might rely strongly on parts of the brain that are also activated during meditation, daydreaming, and other internally focused types of thinking. This network of brain cells is the default mode network (DMN), so called because it's associated with the "default" patterns of thought that happen in the absence of specific mental tasks.

"Unlike most of the functions that we have in the brain, it's not goal-directed," Shofty says. "It's a network that basically operates all the time and maintains our spontaneous stream of consciousness."

The DMN is spread out across many dispersed brain regions, making it more difficult to track its activity in real time. The researchers had to use an advanced method of brain activity imaging to understand what the network was doing moment-to-moment during creative thought. In a strategy most commonly used to pinpoint the location of seizures in patients with severe epilepsy, tiny electrodes are implanted in the brain to precisely track the electrical activity of multiple brain regions.

Participants in the study were already undergoing this kind of seizure monitoring, which meant that the research team could also use the electrodes to measure brain activity during creative thinking. This provided a much more detailed picture of the neural basis of creativity than researchers had been able to capture before.

"We could see what's happening within the first few milliseconds of attempting to perform creative thinking," Shofty says.

Two steps toward originality

The researchers saw that during a creative thinking task in which participants were asked to list novel uses for an everyday item, like a chair or a cup, the DMN lit up with activity first. Then, its activity synchronized with other regions in the brain, including ones involved in complex problem-solving and decision-making. Shofty believes this means that creative ideas originate in the DMN before being evaluated by other regions.

What's more, the researchers were able to show that parts of the network are required specifically for creative thought. When the researchers used the electrodes to temporarily dampen the activity of particular regions of the DMN, people brainstormed uses for the items they saw that were less creative. Their other brain functions, like mind wandering, remained perfectly normal.

Eleonora Bartoli, Ph.D., assistant professor of neurosurgery at Baylor College of Medicine and co-first author on the paper, explains that this result shows that creativity isn't just associated with the network but fundamentally depends on it.

"We moved beyond correlational evidence by using direct brain stimulation," she says. "Our findings highlight the causal role of the DMN in creative thinking."

The activity of the network is changed in several disorders, such as ruminative depression, in which the DMN is more active than normal, possibly related to increased dwelling on negative internally directed thoughts. Shofty says that a better understanding of how the network operates normally may lead to better treatments for people with such conditions.

By characterizing the brain regions involved in creative thought, Shofty hopes to ultimately inspire interventions that can help spark creativity. Shofty says, "Eventually, the goal would be to understand what happens to the network in such a way that we can potentially drive it toward being more creative."

More information: Eleonora Bartoli et al, Default mode network electrophysiological dynamics and causal role in creative thinking, *Brain* (2024). DOI: [10.1093/brain/awae199](https://doi.org/10.1093/brain/awae199)

Provided by University of Utah Health Sciences

Brain cells can be broadly divided into two categories: inhibitory and excitatory neurons. Excitatory neurons are cells that support the generation of electrical impulses in postsynaptic neurons, thus prompting the activation of cells in specific brain regions. Inhibitory neurons, on the other hand, contribute to inhibiting these electrical impulses and thus reducing activity in specific brain regions.

The balance between inhibition and excitation contributes to the healthy functioning of the brain. While the neurobiological processes underpinning the fine-tuning of excitatory neurons are now well understood, those underlying the fine-tuning of inhibitory neurons remain elusive.

Researchers at McGill University and University of Edinburgh carried out a study aimed at better understanding the principles governing the fine-tuning of both excitatory and inhibitory neurons in the mouse postsubiculum, a region in the brain's medial temporal lobe known to support spatial navigation and memory.

Their [findings](#), published in *Nature Neuroscience*, validate the hypothesis that the equivalent tuning of excitatory and inhibitory neurons is an intrinsic property of local cortical networks.

"Our laboratory is interested in how information about the outside world is reflected in the activity of individual brain cells," Adrian J. Duszkievicz, lead author of the paper, told Medical Xpress.

"The mammalian brain is made of millions of brain cells, called neurons, forming billions of connections, and cracking its code knowing the activity of only a fraction of those brain cells is a challenging task. Still, in some parts of the brain activity of individual neurons is relatively straightforward to interpret, and if we study such circuits in detail we may discover some more general principles of how activity of individual brain cells relates to the outside world."

Cells that engage in fairly straightforward patterns of activity include neurons in the primary visual cortex, which become active in response to visual stimuli. Other examples of these cells are place cells in the hippocampus and grid cells in the medial entorhinal cortex, both of which exhibit patterns of activity that are closely related to an animal's location in its surrounding environment.

The existence of grid cells was first unveiled almost two decades ago and the team who discovered them received the 2014 Nobel Prize in Physiology/Medicine.

"Both place cells and grid cells belong to the class of 'excitatory' cells, that is, brain cells that activate other brain cells they connect to," Duszkievicz explained. "Such cells constitute a majority of neurons in the cerebral cortex (~85%), while remaining neurons largely belong to another cell class, called 'inhibitory' cells, which decrease the activity of cells they connect to."

Past studies have found that the activity of excitatory cells, including neurons in the primary visual cortex and place cells, is closely connected to environmental features. Inhibitory cells, on the other hand, tend to be permanently active and their activity can only be slightly modulated by external/environmental events.

The primary objective of the recent work by Duszkievicz and his collaborators was to better understand the origin of inhibitory cell activity. Specifically, the team set out to determine whether the activity of these cells is really random, or whether it follows a particular pattern.

"To do this, we turned to another part of cerebral cortex—a brain area called postsubiculum, that is dedicated to the sense of orientation in space,"

Duszkiewicz said. "Excitatory cells in postsubiculum are called 'head-direction cells' because each of them is active when the animal is facing a particular direction, and together they form the brain's equivalent of a compass, accurately tracking the animal's orientation in the environment."

The researchers decided to focus their efforts on the mouse postsubiculum because this brain region is known to have a very simple neural code. The simplicity of its code allowed them to map out the activity patterns of individual neurons simply by tracking the direction in which a mouse was moving while it was exploring a box.

"We used miniature electrode arrays that we implanted into the brains of mice and aimed at the postsubiculum," Duszkiewicz said. "This technique allowed us to track activity of dozens of individual neurons, up to 180 at a time, while the mice were foraging for cereal in a large box."

Most of the neurons examined by the researchers, namely the mice's excitatory head-direction cells, were only active when the mice were facing a specific direction. The team also observed some inhibitory neurons that were active all the time and yet appeared to prefer seemingly random sets of directions.

"When we took a closer look at activity patterns of neurons in postsubiculum, or their 'tuning' to the animal's direction, we realized that tuning of inhibitory neurons was not exactly random," Duszkiewicz said. "By looking at their activity alone we were able to determine which way the mouse is currently looking, with similar accuracy to excitatory cells, which means that their activity was meaningful. But more importantly, their activity patterns looked as though they summed the activity of all neighboring excitatory neurons—the canonical head-direction cells."

Interestingly, the researchers found that the patterns of activity of inhibitory neurons did not appear to be at all influenced by inputs originating from other brain areas. In contrast, they appeared to be entirely determined by the tuning of nearby excitatory neurons.

Duszkiewicz and his colleagues defined this interplay between the tuning patterns of excitatory and inhibitory activity as "excitatory/inhibitory equivalence." Specifically, their findings show that the tuning patterns of

excitatory and inhibitory cells are comprised of the same components and inhibitory patterns are the sum of excitatory patterns.

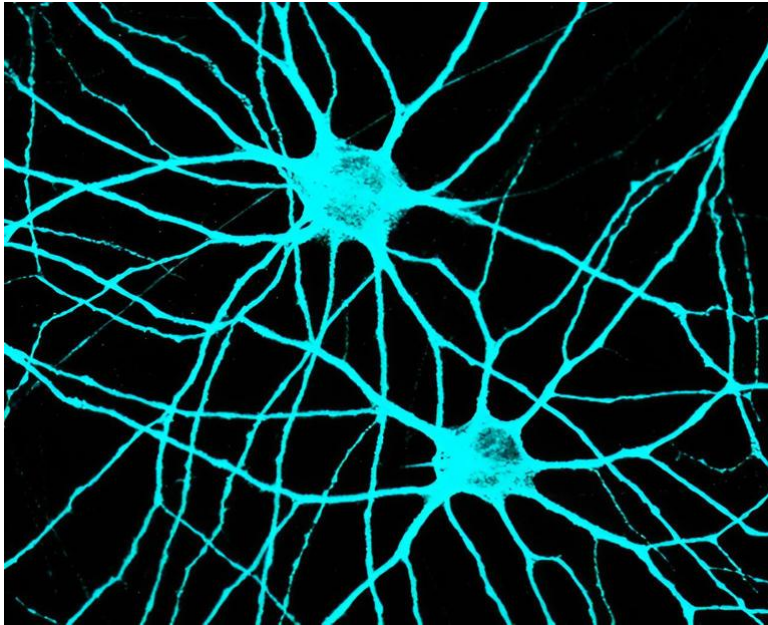
"We think that this finding brings us closer to understanding how the two neuron classes, the excitatory and inhibitory cells, work together to create a mental map of the outside world inside the brain," Duszkievicz said. "This could be particularly important in the age of artificial neural networks, as it puts some constraints on how individual nodes of artificial neural networks should map to the external world if those networks are to model the activity inside real brains."

The results gathered by Duszkievicz and his collaborators shed some new light on the local origins of excitatory and inhibitory tuning in the mammalian brain. While their recent study focused on the postsubiculum, the team hopes to soon broaden their investigation and examine other brain regions.

"Up until now, we have only focused on one neural circuit, the postsubiculum, because its activity patterns are relatively easy to understand," Duszkievicz added.

"Yet now that we know what to look for, we want to confirm that this excitatory/inhibitory tuning equivalence can be observed in brain areas with more complex activity—such as the grid cells in the medial entorhinal cortex. Another avenue we will pursue in our future work is looking more closely at different sub-classes of inhibitory neurons (of which there are many), to see if they show any differences in their tuning to the animal's orientation."

More information: Adrian J. Duszkievicz et al, Local origin of excitatory–inhibitory tuning equivalence in a cortical network, *Nature Neuroscience* (2024). DOI: [10.1038/s41593-024-01588-5](https://doi.org/10.1038/s41593-024-01588-5)



Human neurons derived from stem cells by Assistant Professor Soham Chanda and his team at Colorado State University. Credit: Colorado State University© Provided by Medical Xpress

Newly published research from Colorado State University answers

fundamental questions about cellular connectivity in the brain that could be useful in the development of treatments for neurological diseases like autism, epilepsy or schizophrenia.

The work, [highlighted](#) in the *Proceedings of the National Academy of Sciences*, focuses on how neurons in the brain transmit information between each other through highly specialized subcellular structures called synapses. These delicate structures are key to controlling many processes across the nervous system via electrochemical signaling, and pathogenic mutations in the genes that impair their development can cause severe mental disorders.

Despite their important role in linking neurons across different brain regions, the way synapses form and function is still not well understood, said Assistant Professor Soham Chanda.

To answer that fundamental question, Chanda and his team in the Department of Biochemistry and Molecular Biology focused on a specific and important type of synapse called GABAergic. He said neuroscience researchers have long

hypothesized that these synapses might form because of a release of GABA and the corresponding sensing activity between two neurons in proximity. However, research in the paper now shows that these synapses can begin to develop autonomously and apart from that neuronal communication, mainly due to the scaffolding action of a protein called Gephyrin. These findings clarify the key mechanisms of synaptic formation, which might allow researchers to further focus on synapse dysfunction and health treatment options.

WHO Confirms Physician Consensus on Cell Phone Use and Brain Cancer

Chanda's team used human neurons derived from stem cells to develop a model of the brain that could rigorously test these relationships. Using a gene-editing tool called CRISPR-Cas9, they were able to genetically manipulate the system and confirm the role of Gephyrin in the synapse formation process.

"Our study shows that even if a pre-synaptic neuron is not releasing GABA, the post-synaptic neuron can still put together the necessary molecular machineries prepared to sense GABA," Chanda said. "We used a gene-editing tool to remove the Gephyrin protein from neurons, which largely reduced this autonomous assembly of synapses—confirming its important role irrespective of neuronal communication."

Using stem cells to advance understanding of neuron and synapse formation

Neuroscientists have traditionally used rodent systems to study these synaptic connections in the brain. While that provides a suitable model, Chanda and his team were interested in testing synapse properties in a human cellular environment that could eventually be more easily translated into treatments.

To achieve this, his team cultivated human stem cells to form brain cells that could mimic the properties of human neurons and synapses. They then conducted extensive high-resolution imaging of these neurons and tracked their electrical activities to understand synaptic mechanisms.

Chanda said that several mutations in the Gephyrin protein have been associated with neurological disorders like epilepsy, which alters neuronal excitability in the human brain. That makes understanding its basic cellular function an important first step towards treatment and prevention.

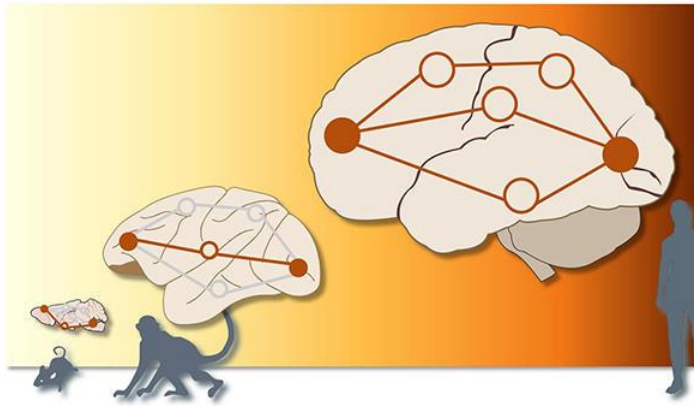
"Now that we better understand how these synaptic structures interact and organize, the next question will be to elucidate how defects in their relationships can lead to disease and identify the ways one can predict or intervene in that process," he said.

More information: Etta Carricaburu et al, Gephyrin promotes autonomous assembly and synaptic localization of GABAergic postsynaptic components without presynaptic GABA release, *Proceedings of the National Academy of Sciences* (2024). DOI: [10.1073/pnas.2315100121](https://doi.org/10.1073/pnas.2315100121)

Information doesn't make its way [around our brains](#) in the same way as it does in the brains of other animals, according to a new study, and it could teach us something important about the way our species has evolved.

A team led by researchers from the Swiss Federal Institute of Technology in Lausanne (EPFL) in Switzerland used advanced data analysis techniques on top of [functional magnetic resonance imaging](#) (fMRI) scans to analyze brain activity in humans, mice, and macaques.

Comparing the resulting brain 'traffic maps', the researchers found that the human brain uses multiple parallel pathways to shift information from one region to another, whereas the mice and macaque brains use just single channels.



Our brains can use multiple channels. (Alessandra Griffa CHUV/EPFL CC BY-SA)© Provided by ScienceAlert

"What's new in our study is the use of multimodal data in a single model combining two branches of mathematics: graph theory, which describes the polysynaptic roadmaps; and information theory, which maps information transmission (or traffic) via the roads," [says](#) Alessandra Griffa, a biomedical engineer from EPFL.

"The basic principle is that messages passed from a source to a target remain unchanged or are further degraded at each stop along the road, like the telephone game we played as children."

To use another analogy, the information traffic moving around the brain is like traffic traveling down a road with multiple stops along the way. Our brains seem [to be wired](#) to simultaneously use multiple roads to get the convoy of signals to its destination.

What's more, the researchers discovered that these parallel pathways are as unique [as fingerprints](#): studying the particular way that information flows around a brain can distinguish individual nervous systems.

"Such parallel processing in human brains has been hypothesized, but never observed before at a whole-brain level," [says](#) Griffa.

How these multiple channels affect thought processing, and why we have them when other animals don't, is beyond the scope of this study. However, the researchers think our larger brains have enabled more complex [patterns of connectivity](#).

AMAZING PSYCHOLOGICAL FACTS ABOUT BRAIN YOU SHOULD KNOW

It might also add some level of resilience to the human brain, the researchers suggest. If one channel gets blocked or damaged, then it's possible that information can be rerouted through another channel instead.

Further down the line, the research could help us determine how damage from brain injuries could be repaired, or how we might be able to guard against the development of conditions [such as dementia](#).

"We could hypothesize that these parallel information streams allow for multiple representations of reality, and the ability to perform abstract functions specific to humans," [says](#) Griffa.

"We looked at how information travels, so an interesting next step would be to model more complex processes to study how information is combined and processed in the brain to create something new."

Scientists have charted a comprehensive map of the brain cells responsible for keeping us awake. In doing so, they aim to better understand the mechanisms that enable human consciousness and to improve treatments for people in comas and vegetative states.

"It's a beautiful study," said [Dr. Nicholas Schiff](#), a professor of neurology and [neuroscience](#) at Weill Cornell Medicine who was not involved in the new research. "It's a map of everything."

Schiff, who has collaborated with some of the study's authors in the past, hopes the new map can serve as a template for scientists to go back and look at patients with altered states of consciousness. Such work could help clarify exactly how this wakefulness network can be disrupted and what's required to get it back online. It's a tool that could help scientists pinpoint which brain activity is "necessary and sufficient" to keep someone awake and aware, Schiff told Live Science.

The new study was published Wednesday (May 1) in the journal [Science Translational Medicine](#).

Mapping consciousness

Human consciousness arises from a delicate dance between the wrinkled surface of the brain, known as the cerebral cortex, and deeper "subcortical" structures beneath it. Circuits in the cortex direct our attention and process information from the world around us, while the subcortical networks plug into these circuits from below, essentially keeping them active.

"It sends the signals that activate and stimulate the entire rest of the brain," said first author [Dr. Brian Edlow](#), co-director of Mass General Neuroscience and director of the Laboratory for NeuroImaging of Coma and Consciousness.

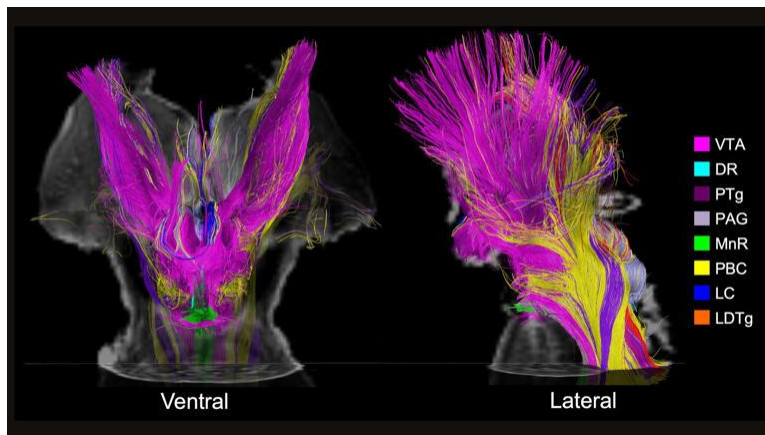
Thus, consciousness is a "seamless interaction of these subcortical networks with these cortical networks," Schiff said. "It's an artifice, I think, to try to separate these things."

But scientists' understanding of humans' subcortical networks is incomplete. It relies heavily on animal experiments, in which scientists can inject trackable chemicals into the brain and then remove the organ to get a good look at where they ended up. In living humans, these deep-seated networks are located near major arteries and air-filled sinuses, and they also move a bit with each breath, making standard brain scans less crisp and hard to decipher. By contrast, networks in the human cortex are easier to image and have been much better studied.

To help close this knowledge gap, the scientists behind the new study looked at brains from three middle-age organ donors. Using postmortem brains allowed the team to "map brain networks at ultrahigh resolution and to see connections that simply cannot be seen when you're scanning a living human being," Edlow told Live Science.

These organ donors had no neurological problems when they died, and their brains were carefully preserved in formaldehyde. The researchers stained the

brains with colorful chemicals to mark different types of brain cells and then put the brains in an magnetic resonance imaging (MRI) scanner for up to 48 hours.



These scans of postmortem brain tissue show many of the tracts in the network that sustains wakefulness in humans. (Image credit: Edlow et al., Sci. Trans. Med., 16 eadj4303 (2024). (Cropped by Live Science.))© Provided by Live Science

This resulted in incredibly high-resolution maps of subcortical structures that had been tied to wakefulness in previous research. The team manually traced connections between the brain cells in these structures, taking into account the direction water would flow down their wires. This metric captured by MRI can help reveal how strongly different nodes in a network are linked.

This work revealed major nodes of the wakefulness network in several subcortical structures — the brainstem, hypothalamus and thalamus — as well as part of the cortex called the basal forebrain. This network was confirmed to be linked to a circuit involved in awareness. Known as the [default mode network](#), it is very active when we're daydreaming and not focused on a particular task.

To back up their work in postmortem brains, the team also looked at functional MRI data from more than 80 people who'd participated in the [Human Connectome Project](#), a government-led effort to map all the networks in the human brain. These additional brain scans, which looked at the flow of oxygenated blood, pointed out a hub where these awareness and wakefulness networks meet: the ventral tegmental area.

Taken together, the postmortem brain scans provided maps of highways in the brain, while the live scans showed traffic patterns along those roads. "We view our findings as an initial map that is beyond the spatial resolution that has been achieved previously," Edlow said. Looking to the future, the researchers hope to improve upon the map's resolution even more.

At this point, it's unclear exactly how the new map could shape the treatment of patients in comas, vegetative or minimally conscious states, Schiff noted. But it should be a useful tool to better understand and treat these conditions, he added.

"We envision that these connectivity maps will allow us to piece together, one individual at a time, the combination of connections that are necessary and sufficient to recover consciousness," Edlow said.

Scientists have created an "exceptionally bright" light source that can generate quantum-entangled photons (particles of light) which could be used to securely transmit data in a future high-speed quantum communications network.

A future quantum internet could transmit information using pairs of [entangled photons](#) — meaning the particles share information over time and space regardless of distance. Based on the weird laws of [quantum mechanics](#), information encoded into these entangled photons can be transferred at high speeds while their "quantum coherence" — a state in which the particles are entangled — ensures the data cannot be intercepted.

But one of the key challenges in building a quantum internet has been that the strength of these photons can fade the further they travel; the light sources have not been bright enough. To build a successful quantum internet that can send data over vast distances, photons must be strong enough to prevent "decoherence" — where entanglement is lost and the information they contain disappears.

Quantum mechanics is our fundamental framework for understanding the physics.

Paul Explains: Quantum Mechanics

In research published 24 July in the journal [eLight](#), scientists from Europe, Asia and South America created a new type of quantum signal source using existing technologies that achieves extremely high brightness.

They achieved this by combining a photon dot emitter (a generator of single photons, or a particle of light) with a quantum resonator (a device to strengthen the quantum signature) to create the powerful new quantum signal.

What makes the recent research especially interesting is that the individual technologies have been independently proven in laboratories, but they had only been tested separately. This study is the first time they have been used in conjunction with each other.

Researchers combined the photon dot emitter with a circular Bragg resonator (a reflector used to guide electromagnetic waves) on a piezoelectric actuator (a device that generates electricity when heat or stress is applied). Together they created an enhanced form of photon emitter, which can fine-tune the emitted photons for maximum polarized entanglement. This was controlled by using the piezoelectric actuator.

Photon pairs generated by the device had a high entanglement fidelity and extraction efficiency — meaning that each photon is bright enough to be useful and holds its "quantum signature" (a useful quantum property) well. It was previously hard to achieve both a useful level of brightness and a high entanglement fidelity at the same time, because each aspect required a different technology and these were difficult to combine in a scalable manner.

This is a significant step forward in developing practical quantum technologies, demonstrating how they can be combined together to create a more powerful and viable light source.

Unfortunately, we should not expect a quantum internet any time soon, as the various technologies remain in the experimental and development phase. Making the photon emitter used in the study also required toxic raw materials, including arsenic, which required specialist handling. There are also safety concerns around the use of gallium arsenide, which the photon dot emitter was made from. [Fisher Scientific](#), a supplier of laboratory equipment and chemicals for scientific research, [lists](#) gallium arsenide as hazardous for several reasons, including its carcinogenic properties.

The safety concerns relating to the use of these materials could limit the scalability of the methodology outlined. Viable alternative materials may

therefore need to be identified in generating bright, entangled photons for future quantum communications network

The next stage in the development process will be to integrate a diode-like structure onto the piezoelectric actuator. This would allow an electric field to be generated across the quantum dots, in order to counteract decoherence and therefore boost the degree of entanglement.

Although there are many further steps to take in developing a quantum internet, successfully combining a photon emitter and a resonator to achieve photons with high brightness and entanglement is nonetheless a significant step forward, the scientists said.

From [Google Glass](#) to [Magic Leap](#) to [Oculus Rift](#), there have been numerous attempts to get wearable computers in front of your eyes. But none have changed how we interact with technology in the way their promoters imagined. Qualcomm CEO Cristiano Amon has hinted that technology heavyweights aren't done trying, though. Amon says his firm is working with Samsung and Google on mysterious new mixed reality smart glasses—but don't expect an Apple Vision Pro competitor.

In an interview with CNBC, Amon noted that the companies had agreed to work together to develop smart glasses that he describes as "mixed reality" as opposed to virtual reality. That suggests it will superimpose data and visuals on top of the real world rather than enclosing users in a virtual environment with optional passthrough video. That's the approach currently in use at Apple and Meta, which makes the most popular wearable computers.

Meta and Apple have designed their headsets with powerful processors and sharp integrated displays, which make the hardware expensive and heavy but capable of standalone operation. Amon says its unnamed smart glasses project will take a different approach, acting as an accessory for your phone.

"It's going to be a new product, it's going to be new experiences," [said](#) Amon. "But what I really expect to come out of this partnership, I want everyone that has a phone to go buy companion glasses to go along with it."

Qualcomm CEO discusses AI on the 'edge'

Those "new experiences" will have to be compelling, though. Truly useful smart glasses have been slow to arrive. It's difficult to balance performance and battery life in wearable devices, particularly gadgets that are supposed to remain perched on your face all day. The simpler approach hasn't been great, either. The [Meta Ray-Ban smart glasses](#) barely do anything other than play music and take grainy photos—there isn't even a display.



Snapdragon AR2

Qualcomm has already developed chips for smart glasses. Credit: Qualcomm Amon says AI will be a key aspect of the glasses, and Google is investing heavily in that technology and developing the Android operating system for phones that the glasses will have to talk to. Samsung, meanwhile, is the largest manufacturer of Android phones and a major producer of OLED panels and similar display tech that will be essential for such a product. And then there's Qualcomm, which produces some of the most efficient mobile chipsets, including the Snapdragon AR2 Gen 1 for smart glasses.

Neither Google nor Samsung have commented directly on Amon's statements. Still, Samsung mobile chief TM Roh did mention several months ago his firm would announce a new mixed-reality platform within a year. There's no guarantee this partnership will bear fruit—we may never hear about it again, or the eventual product could be a mere blip on the radar. However, this group of companies theoretically has the expertise to make a go of it.

Of everything we've seen in 2024, smart glasses are proving to be a genuine hot property. While wearables such as Samsung's Galaxy Ring are making headlines and bringing the smart ring into the limelight, smart glasses — [a wearable wonderkid a decade in the making](#) — are also beginning to come into focus.

But how do you know that a product is likely to force its way into the mainstream and become one of the next must-have devices for years to come? Well, there's market speculation from well-established analysts or a growing buzz among tech outlets. However, there's also potentially the biggest nod towards the success of any given device, the news that Apple is making one too.

Apple once sneered and derided its competitor's initial efforts at bringing smart glasses to the consumer market, but, ten years removed from the ill-fated [Google Glass](#), the company is currently committed to releasing its own smart glasses, and it could lead to the mainstream moment this wearable has been waiting for.

Apple smart glasses: What we know

While Apple is a company well known for having any number of irons in the fire at one time, we can never say for certain that its behind-closed-curtains collection of in-the-works projects will materialize into anything that lands on store shelves.

However, when it comes to smart glasses, things are looking ever more likely to progress with *Bloomberg's* resident Apple auteur Mark Gurman highlighting Apple's commitment to the project in his latest [Power On newsletter](#).

iPhone 14 and Planned Obsolescence

The long-standing "Apple Glass" rumors will seemingly take their first steps into realization as Apple's Vision group continues to expand on the company's new face-worn focus that kickstarted with this year's release of the Vision Pro.

However, while the Vision Pro immediately dove into the deep end of high-tech headsets, offering one of the most premium experiences we've seen so far, Apple's first venture into smart glasses could be a much more modest matter.

Apple smart glasses: What to expect

While it's long been the rumor that Apple is looking towards developing a pair of "true" AR smart glasses, Gurman states that "true augmented reality glasses has been tabled due to technical challenges," the company's first pair of smart glasses could more clearly resemble the [Meta Ray-Ban Smart Glasses](#), which released in October last year.

Meta's frames refine the smart glass experience by offering a Bluetooth and Wi-Fi-enabled pair of Ray-Ban's iconic Wayfarer sunglasses that offer touch capacitive controls for handling calls and music playback through open-ear speakers, housed directly within the temples of the frames.

If Apple hopes to emulate Meta's success in this market, then it's more than capable of providing a similar, if not superior, experience.

Taking this another step further, the Meta Ray-Ban smart glasses also feature a built-in ultrawide 12-megapixel camera and multi-mic system for image and video capture from the first-person perspective.

However, the cherry on top of Meta's smart glasses came with the arrival of Meta AI, which allowed hands-free access to the company's premier multi-modal AI chatbot. Wearers can interact with Meta AI through natural language prompts in a similar way to smart home assistants. Simply saying "Hey Meta..." activates the onboard assistant allowing wearers to engage with the AI.

The AI can also [access the glasses' camera to comment and respond based on real-world visual inputs](#) such as translating foreign languages, helping to choose outfits, and giving you more information on landmarks or works of art.

If Apple hopes to emulate Meta's success in this market, then it's more than capable of providing a similar, if not superior, experience.

Apple's smart glasses could draw upon the tech housed a wide range of Apple products to emulate any number of features the Ray-Ban Meta Smart Glasses offer to complete one of the most well-rounded smart glasses offerings we've seen to date.



A concept image of Apple-branded "true" AR glasses imagines how the company's smart glasses ambitions could eventually be realized. (Image credit: Apple)

Apple smart glasses: What we'd like to see

The first generation of Apple smart glasses would do well to draw inspiration from the audio excellence of the AirPods together with the iPhone's quality camera offerings while making great use of the company's all-new [Apple Intelligence](#) AI — not to mention the long-awaited AI Siri overhaul [expected to release next year](#).

Where Apple could go one further is to double up the camera offerings, allowing wearers to capture spatial images and video in full 3D, something already implemented into [iPhone 15](#) models.

Smart glasses also allow for various health and lifestyle tracking capabilities like those features in the [Solos AirGo 3](#), which offers step tracking, posture reminders and correction from its built-in gyroscope, and even an optical heart rate sensor hidden inside one of its temples.

With health and fitness tracking becoming one of Apple's major focuses with the Apple Watch, it's likely that we could see the company adopt a similar approach for its smart glasses.

This would not only expand on what its smart glasses could offer wearers but also help to set the foundations of a future "all-in-one" wearable that could viably replace the iPhone once Apple figures out how best to implement displays into this product.

Will Apple smart glasses replace the iPhone?

It was 2007 when Steve Jobs took to the stage to reveal the iPhone to the world for the first time. Since then, we've seen Apple's smartphone refined, reformed, and redesigned countless times through innovation and invention.

However, over fifteen years on from this landmark announcement, we're finally staring down the barrel of a product that could eventually see the smartphone dethroned as the everyday computing companion.

Likely, this first generation of Apple smart glasses won't be the one to complete such a Herculean task, but the company's "true" AR glasses could well be the ones that pave a new path ahead for personal tech.

Even Meta CEO Mark Zuckerberg believes the eventual release of "true" AR glasses is a ["Holy grail" moment in tech](#), and that's something he and his company are being [heavily linked with showcasing as early as later this year](#).

That being said, Apple's first-generation smart glasses may include a cellular and Wi-Fi option, similar to its iPad and Apple Watch offerings. Thanks to the sleuths at *Patently Apple*, we already know that Tim Cook and Co. are exploring how best to [outfit its future glasses with cellular antennas](#).

While it's unlikely that anyone will be ditching their iPhone for this first-generation device, it seems highly likely that it will be available as a stand-alone device of its own, and not brought to market as an accessory that is iPhone dependent. As for how future iterations are adopted, especially "true" AR glasses, that remains to be seen.

When can we expect them?

With so much potential to be found in Apple's upcoming smart glasses, it's only natural to want to know when we can expect them to release.

While we can't say for certain they will, insiders and analysts believe they're on their way, with the reputable [Ming-Chu Kuo believing that a 2026 release date](#) is possible, with Metalens production likely allowing for Apple to chase its "true" AR glasses dream further down the line.

An even more positive prediction comes again from *Blomberg's* Mark Gurman, who believes we could see Apple's smart glasses [arrive by the end of 2025](#).

Of course, these dates should be taken with a healthy amount of salt, as Apple is no stranger to abandoning projects or delaying them until they're completely satisfied with the end result.

However, with a more stripped-back approach to its smart glasses on the cards, leaving AR out of the equation for the time being, it's very likely that Apple can follow through on its ambitions in a faster manner and capitalize on the growing popularity that this form of wearable has to offer.

What are smart glasses? Yesteryear's 'next big thing' is finally finding an audience

published July 10, 2024

An eyewear revolution you don't want to miss out on



(Image credit: Laptop Mag / Rael Hornby)

Wearable tech has become commonplace in the digital age as everything from watches to rings receive 'smart' overhauls that unlock a slew of new functions for familiar forms, from tracking health metrics to more conveniently interacting with other devices. However, while we can all recognize an [Apple Watch](#), we may be less familiar with other forms of wearable — particularly, smart glasses.

There's good reason for such oversight too. On their initial release into the wilds of the commercial market, smart glasses were more prone to jeers and jibes than shock and awe.

As a glasses wearer, it's plainly obvious to me that my regular frames are bursting with untapped potential.

While the tech was impressive, they were often seen as little more than an expensive status symbol for the tech-obsessed, and a genuine threat to the privacy of anyone not positioned behind their lenses. However, as times have changed, so too have attitudes, and a smart glasses renaissance could be primed to explode in popularity in the very near future.

What makes smart glasses important? Well, when it comes to finding a wearable that can do it all, the answer for many of us is right in front of our faces. Literally. While glasses have helped correct vision for centuries, their form and position on the body make them ideal for providing visual and audio feedback in the most unobtrusive and accessible way possible.

I'm a huge proponent of smart glasses and have been for some time now. As a glasses wearer, it's plainly obvious to me that my regular frames are bursting with untapped potential — and several of my experiments with smart glasses have shown me that they're more than capable of housing all kinds of wonderful tech too.

So, let's take a deeper look at what smart glasses are and some of the frames we'd recommend you become familiar with.



Smart glasses like the XREAL Air 2 AR Glasses are face-worn displays that can project 100-inch virtual screens in front of users. (Image credit: Laptop Mag / Rael Hornby)

What are smart glasses?

Smart glasses, like regular glasses, are face-worn eyewear that can not only help correct vision but also offer additional functionality. They can interact with your other smart devices and computers or work stand-alone to provide media playback, activity tracking, and more.

Although they've been around since 2004, they're only truly beginning to make their presence known in the mainstream.

Why check your phone for notifications when you can be alerted through a heads-up display (HUD)? Why rely on physical screens when you can project content directly in front of your eyes and all around you with augmented reality (AR)? And why let a phone call interrupt you when you can use your smart glasses to receive calls completely hands-free?

Smart glasses offer a new way of being connected to your favorite tech. Although [they've been around since 2004](#), they're only truly beginning to make their presence known in the mainstream. While Google tried its hand at the format in 2014, a generally negative reaction to its camera-adorning frames set the consumer viability of these devices back for some time.

However, consumer attitudes have started to shift. Despite several high-profile flops, wearables are now commonplace (remember, Google Glass was unveiled even before the very first Apple Watch launched), smart glasses sales are [currently predicted to double year-over-year](#), Meta's latest smart glasses have [proven to be a surprise success](#), and the growing popularity of AR and AI has given the [smart glasses form factor rejuvenated use cases](#) — even [Apple is pondering making pair of smart glasses](#) of its own according to one *Bloomberg* report.

The market is now more welcoming than ever to wearables of this sort, with smart glasses morphing into a much more attractive prospect due to the many useful features and capabilities they can offer.



Ray-Ban Meta's smart glasses are better suited to media capture and audio playback, syncing with a smartphone instead of housing its own display. (Image credit: Future)

What types of smart glasses are there?

While smart glasses aren't exactly commonplace, there are a considerable number of manufacturers dedicated to designing frames that offer all kinds of advanced functions.

Because of this, there's no universal example of what a pair of smart glasses must include to be considered as such. However, a majority of smart glasses fall within one or more of the following categories:

- **Smart glasses for media capture:** Mirroring the spy glasses of espionage novels, but hopefully not abused for creepshot potential, some devices like the [Ray-Ban Meta smart glasses](#) use built-in microphones and cameras to capture images and video from a first-person point of view.

These frames are great for those looking to capture some social media snaps, though you'll need a mirror handy if you're interested in taking the perfect selfie.

- **Smart glasses for communication:** One of the more basic smart glasses variants are those designed to replace hands-free headsets for inbound and outbound phone calls.

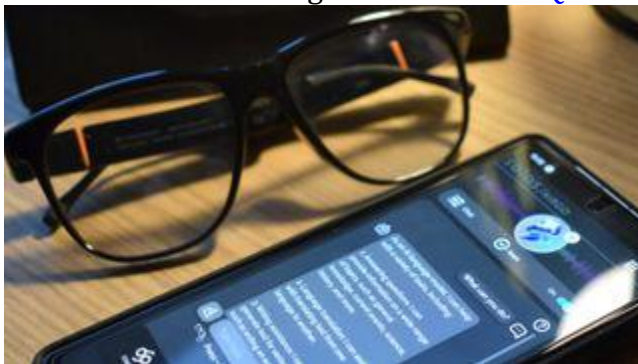
While they lack any of the more fancy display or AR/XR capabilities of premium models, these smart glasses are generally much more affordable and offer built-in microphones and open-ear audio for music playback and call handling.

- **Smart glasses for AI:** Tech's latest craze is undoubtedly AI, and there's a push to infuse large language models (LLMs) into just about every product there is. However, when it comes to smart glasses, there may be no better home for a super-intelligent assistant.

With multi-modal AI models now fairly common, smart glasses like the [Solos AirGo 3](#) and [AirGo Vision](#) offer unique ways to use AI to interact with the world around you using contextual voice, text, and visual information.

- **Smart glasses for AR/XR:** Augmented (or mixed) reality glasses are among the more expensive options on the market. They provide a virtual display for mobile and desktop devices.

AR smart glasses like the [XREAL Air 2](#) and [VITURE Pro XR](#) are also equipped with head tracking sensors capable of providing 3DoF (Three Degrees of Freedom) to floating AR windows. With the right accessories, glasses like these can also offer 6DoF tracking similar to [Meta Quest 3](#) and [Apple Vision Pro](#) headsets.



Frames like the Solos AirGo3 Smart Glasses allow for instant access to ChatGPT via a discrete action button linked to a mobile app. (Image credit: Laptop Mag / Rael Hornby)

Outlook: Are smart glasses the future?

Call me biased, but as I sit here wearing a pair of smart glasses myself, I can say with certainty that these devices are incredibly useful and packed with potential. A pair of

lightweight AR glasses can turn a simple laptop into a multi-screen workstation, while others give you instant access to some of the most powerful [AI](#) models for real-time assistance.

While several of the more popular AR models [excel](#) at delivering compelling entertainment experiences in 2D and 3D media, the potential of smart glasses isn't limited to the living room.

Call me biased, but as I sit here wearing a pair of smart glasses myself, I can say with certainty that these devices are incredibly useful and packed with potential.

As the display tech evolves and software improves, smart glasses will offer more compelling visual aids for navigation, offer real-time visual translation of languages, and adopt hand tracking for more advanced interactions with richer interfaces and AR elements. We're already seeing the latter take shape with [XREAL's latest Air 2 Ultra glasses](#). The potential for this tech is unrivaled among its wearable contemporaries, and we're even beginning to see screenless [AR laptops outfitted with smart glasses](#) enter the market — fully banking on the future of spatial computing.

Are smart glasses a guarantee to take the tech world by storm? Well, that's not so easy to say. Sometimes, even the best ideas don't catch on. However, as the buzz around these devices grows, along with their capabilities and performance, I'd personally say that spatial computing in all of its forms is here to stay, and smart glasses are the best and most obvious way for it to thrive.

Google Glass 2.0: A smart glasses comeback that's long overdue

published May 16, 2024

Is Google reviving a cult Classic?



(Image credit: Google)

Remember Google Glass? It's OK if you don't. Despite promising to be the dawn of augmented reality and a grand leap forward for wearable tech, Google's smart

glasses went out of fashion faster than the Vuvuzela (you'll likely have to Google that one).

However, Google's dream of delivering [AR smart glasses](#) to market might not be as dead in the water as we once thought — and the recently revealed Project Astra may be our best look to date at how it's looking to make that dream a reality. A video released by Google to coincide with Google I/O titled [Project Astra: Our vision for the future of AI assistants](#), showcases an [AI](#) agent, powered by Google's multimodal Gemini AI model, running on both a Pixel phone and a similar pair of prototype smart glasses to the ones last seen in a 2022 [YouTube](#) video titled [Breaking down language barriers with augmented reality](#).

As a genuine backer of smart glasses, and someone who has been lucky enough to review several pairs of the best options on the market, my heart leapt into my mouth when this was revealed. Is there still hope for a Google Glass revival?

The untimely demise of Google Glass

The world of tech is a very strange place. As an industry ceaselessly in the process of invention, innovation, and something else beginning with “i” to follow the rule of three, the tech landscape is in a never-ending state of evolution.

New ideas are constantly being toyed with and tested behind closed doors, and sometimes, not often, but sometimes, a company will eagerly show the world what it's been hard at work on, only to find out that the world was not equipped to deal with what it had to show or was proposing.

Such a thing happened in 2013, and so begins the story of Google Glass.

While not the first to develop a pair of consumer smart glasses, Google's were among the most ambitious — offering hands-free control of a voice-activated augmented reality display for the startling price of \$1,500 (~\$2,000 in today's money adjusted for inflation).



Google Glass was so ahead of its time that I'm amazed the simple folk of 2013 didn't burn Google at the stake for witchcraft. (Image credit: Google)

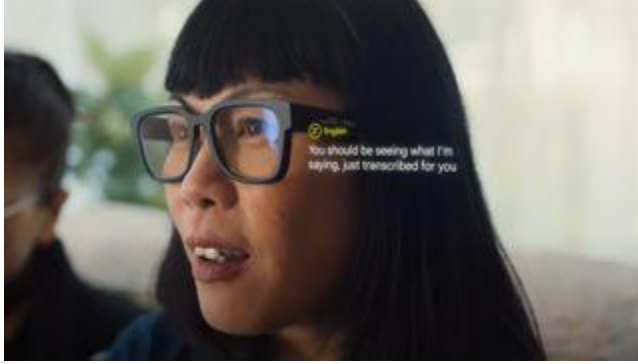
However, in a move that seems incredibly hard to fathom after adjusting to life in 2024, the quaint folk of 2013 were outraged over the fact that Google Glass was outfitted with a built-in camera. Many feared for their privacy (a fear we seem to have completely grown out of just over a decade later), believing it could be used to secretly record them. It was even banned from use in certain public spaces.

The outrage spawned the term "[Glassholes](#)," a pejorative used against anyone rude enough to wear Google's smart glasses out in public spaces. They were mercilessly shamed for adopting this tech, as was Google, who eventually pulled their futuristic frames from public sale in 2015 and repositioned them as enterprise devices until shutting up shop altogether [last year](#).

Google Glass: A long-rumored return

Of course, within that time, humanity collectively stopped caring about its privacy. Now we're mostly a collective of extroverted lens lovers who wouldn't blink twice at an IRL streamer wandering the streets, waving their camera around with reckless abandon.

Even still, Google was once bitten and twice shy when potentially stepping back into the consumer market. The following years were a constant back and forth of will-they-won't-they rumors anticipating a Google Glass 2.0 follow-up — especially when more companies went down the smart glasses route without so much as a mild murmur in their direction.



When we saw Google Glass next, it was primarily showcased as a translation tool. (Image credit: Google)

It was 2022 before we saw anything concrete surrounding [Google's continued smart glasses intentions](#) with our first look at a prototype pair of next-gen smart glasses. But even then they'd dropped the built-in camera for an audio-only approach to its wearable. Then, after [Apple](#) announced the Vision Pro in June 2023 Google reportedly [ditched its Glass plans again](#).

Even Google's Senior Director of Engineering for XR and AR projects at the time walked from the project and the company, [taking to Twitter \(now X\) to state his key reasons for leaving](#) being "recent changes in AR leadership and Google's unstable commitment and vision have weighed heavily on my decision."

At this stage, it was seemingly all over (again). That is, until October 2023, when code was spotted within the Google app for [Android](#) that pointed towards "Iris," one of the project names believed to be associated with a Google Glass follow-up. This brings us right the way around to this year's Google I/O, and Project Astra.

Project Astra: The Glass is half full

So what are the chances that Google is giving us a hint at things to come with its Astra video? Well, not zero.

While there have been reports that Google was planning to focus solely on software, developing an AR platform for OEMs to make use of in their own hardware (something desperately needed for current smart glasses manufacturers to take the next step toward the mainstream) Google I/O did see [co-founder Sergey Brin hinting at augmented-reality glasses making a return](#) with the help of AI, which is exactly what the Project Astra video showcased.

Whether or not this means Google is officially back in the smart glasses business remains to be seen. But it does leave the doors wide open if it should decide to do so. As the now-dormant [Google Glass website](#) states: "The journey doesn't end here."

AR Smart glasses are everything the Vision Pro should have been

By [Rael Hornby](#)

published April 23, 2024

Mark my words, smart glasses are the future

When you purchase through links on our site, we may earn an affiliate commission. [Here's how it works.](#)



(Image credit: Laptop Mag / Rael Hornby)

[Apple's](#) Vision Pro was supposed to be a game changer, a harbinger of spatial computing. It housed the most cutting-edge tech, was made from the most premium of materials, and was designed to operate in total harmony with the wider Apple ecosystem. That's why it was such an overwhelming success, and, to this day, hailed as one of Apple's most successful product launches of all time.

Except it wasn't.

Apple Vision Pro: A fate sealed with a K.I.S.S.

Keep it simple, stupid (KISS) is a design principle and acronym that pushes for products and systems to avoid complexity wherever possible. This is an especially good design mentality to have when you want to introduce something new to a larger audience, as it gives them far less to have to adapt to.

Apple managed this pretty well for devices like the iPod, [iPhone](#), and iPad. To use them, you simply turn them on and tap. Sure, further features require a little more know-how and these systems evolved in complexity over time, but the general usage is simple. Seeking to introduce a new type of product to a wider audience, Apple designed its Vision Pro with the same ease of use in mind. Subtle finger gestures allow you to interact with the "spatial computing" environment around you, with the very direction of your pupils serving as a pointer of sorts.



The Apple Vision Pro's weight proved to be an issue for many users post-release. If only they'd have listened well in advance... (Image credit: Laptop Mag / Rael Hornby)

That's pretty simple and pretty intuitive. However, tack onto this the need to scan your face to build a digital clone of yourself, calibrate your own fingers to engage in awkward zero-feedback interactions, control everything via gesticulation that leaves you looking like you're attending the most low-energy rave mankind ever bore witness to, and then having to [head on over to Reddit for medical opinions on how to strengthen your neck muscles](#) enough to wear this behemoth without developing scoliosis, and you're beginning to push at the boundaries of how simple and intuitive things really are.

It's just a lot to throw at somebody at once. It's a whole new medium, method of interaction, and an entirely different type of wearable (that isn't all that wearable). By the time you get to the Vision Pro's weak selection of proprietary apps and its \$3,500 price tag, it's very hard not to see this thing as a supremely over-specced stereoscopic View-Master.

Sadly, we're just a little too early on into this tech's life cycle and there's nothing else out there to provide a simpler, affordable, and more comfortable all-day AR experience.

Except there is.

Enter, eyewear 2.0: The smart glasses revolution you aren't paying attention to

If you haven't heard, smart glasses are the next big thing. Says who? Says me, dear reader. That's who. What do I know? Well, actually, a fair bit.

I've been wearing smart glasses of various forms for over six months now. While I can confirm I'm basically as cognitively defunct as I was before putting them on, I can say there's genuine promise when it comes to eyewear 2.0 technology.

They're lightweight, easy to use, stay completely cool, and (generally speaking) completely unobtrusive. Plus, you don't have to walk around with a pair of digital googly eyes plastered to the front of your face.

While many people were slowly coming to grips with the fact that I was right when I said that [there's no way anyone is wearing the Vision Pro for a full day's work](#), I was busy saying my farewells to the flat screen and [using AR Glasses to replace my monitors](#).



Solos' AirGo3 Smart Glasses have ChatGPT built-in, giving you one touch access to the world's most popular AI chatbot. (Image credit: Laptop Mag / Rael Hornby)

I even switched out my regular eyewear for a pair of [Solos AirGo 3 Smart Glasses](#), and by switched out, I mean I've yet to return to my regular old spectacles 1.0 lifestyle. And why would I? Thanks to Solos' smart glasses I now have the power of [ChatGPT](#) perched atop my face at all times. I'm practically a demigod.

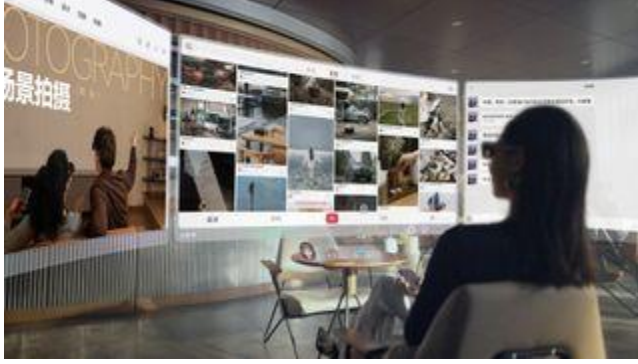
When it comes to entertainment I can always [switch](#) over to AR glasses, enjoying a 120-inch projection of a display anywhere at any time with impressive open-ear audio for more natural immersion. Typically all this requires is connecting a cable and I'm good to go. While I might have eventually returned to monitors, I did so begrudgingly and only because I needed to perform a lot of multitasking that the software powering these augmented eyeglasses wasn't quite capable of yet. Sadly, this goes to show that even your favorite tech has its limitations, and I'm forced to twiddle my thumbs while I wait for a more ideal solution to present itself.

Except it has.

Rokid's AR Lite spatial computing suite: The smart glasses combo you didn't know you needed

I'll forgive Rokid for adopting the spatial computing Apple marketing slang, but only because it has just announced the smart glasses product I've been banking on.

Rokid's AR Lite is a bundle of two new products: the ultra-lightweight Rokid Max 2 AR smart glasses and the Rokid Station 2 host unit—an easy to operate touch interface that uses the proprietary YodaOS-Master spatial operating system to power expanded AR functions.



The Rokid AR Lite Suite offers multiscreen multitasking all in augmented reality across virtual screens up to 300-inches in size. (Image credit: Rokid)

It's those AR improvements that change everything for the Rokid Max 2, with the new AR lite suite combining to provide **multi-screen support for AR windows** up to **300-inches** in size, **picture stabilization** for use while on the go or in a moving vehicle, **wireless multi-platform screen casting** to spatial **windows**, and **expanded Bluetooth connectivity** for external peripherals alongside **100GB of free cloud storage** that unshackles you from the confines of your dreary desk throughout your 9-to-5 misery—especially when taking into account the host unit's **5,000mAh battery**.

Not only that, those "spatial computing" capabilities are backed by the Rokid Max 2 smart glasses already impressive features like **non-destructive Diopter adjustment** (0.00D to -6.00D), which sounds fancy, but is actually a set of in-frame dials to tune-in the display to suit near-sighted users without the need for prescription lenses.

The AR Lite Suite's Rokid Station 2 host unit can be controlled through simple touch gestures, or held in the hand and used as a controller-like pointer device. (Image credit: Rokid)

As a stand-alone set of smart glasses the lightweight (just 75 grams) Rokid Max 2 can also deliver a **300-inch, FHD, TÜV Rheinland-approved eye-friendly display** at **600 nits** of peak brightness, at 1200p resolution with a **90Hz refresh rate**. Then there's the built-in **HiFi-level open-ear audio** that leaves you free to engage with the environment around you in complete comfort without skipping out on immersion for your chosen media.

Outlook

As one of the latest and more promising wearable options, smart glasses are becoming better and better all of the time. Rokid's AR Lite Suite is just the most recent example of this, and highly unlikely to be the last.

This tech is destined for big things, and you can bet your bottom dollar that Apple, [Meta](#), and more all have their sights set on condensing VR/AR headsets into this form factor as soon as it's humanly possible to do so.

In the meantime, Rokid's AR Lite Suite will be available direct from the [Rokid website](#) following the coming launch of its Kickstarter.

AI glasses could be the next big trend

AI glasses are expected to be the next big hit shortly with almost everyone wishing to own a pair of the set on the back of their abilities, reports say.

Combining capabilities ranging from AI voice assistant with AR holographic visuals and other features and functionalities of Bluetooth earbuds, having a pair of these glasses, according to Compute World, will make one feel special, like they know everything and are constantly aided by AI.

AI glasses to bring Sci-Fi to reality

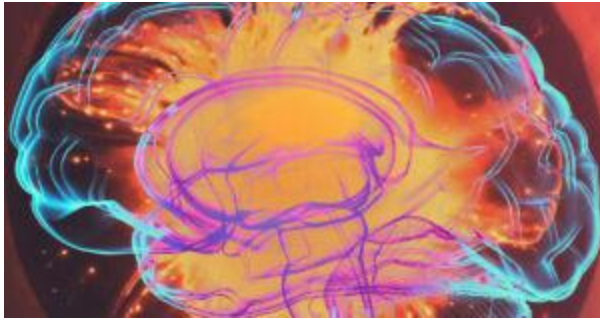
In one of his movies, Mission Impossible Dead Reckoning 1, Tom Cruise, who plays the character of Ethan Hunt, wears augmented AI-powered glasses to aid his fight against the bad guys.

If global technology giants' plans materialize, similar devices may be part of our daily lives, as there is an emerging race of companies rushing to capture the AI-powered glasses market.

According to reports, Snap Incorporated, an American company that manufactures futuristic eyewear, and Meta, one of the biggest investors in the metaverse, are both preparing to launch AI-powered glasses soon.

Although both companies have kept any insights into the products under lock and key, it is suspected that these products may be a few weeks away and expected to be a hit.

Meta is expected to unveil their *Orion* glasses at the Connect Conference, scheduled for September 25 and 26.



A biologist with the US government's research and development arm is working on a radical new approach to anti-aging treatments.

A biologist with the US government's research and development arm is working on a radical new approach to anti-aging treatments: replacing parts of the human brain with cloned tissues.

As the [MIT Technology Review reports](#), researcher Jean Hébert was [recently hired](#) by the US Advanced Projects Agency for Health (ARPA-H) for his revolutionary plan to bring for "functional brain tissue replacement."

Created in 2022 by President Joe Biden as a medical "[moonshot](#)" incubator, ARPA-H is all about funding the kind of "bold, urgent innovation" presented by researchers like Hébert. His brain tissue-cloning theory, however, may be a bit more far-out than the AI schemes and MRI updates being [funded by the agency](#).

While there are already transplants for things like hips and kidneys, the concept of replacing one brain for another is terrifying on an existential level because on a fundamental level, our brains make us who we are.

Hébert's research, however, is more focused on "progressively" replacing *parts* of the brain using young, lab-grown tissues. If done slowly enough, the *Tech Review* explains, the idea is that the brain could adapt by moving around memories and other key identity facets to accommodate its new biological material.

A genetics and neuroscience professor at the Albert Einstein School of Medicine in The Bronx, Hébert has already begun setting the groundwork for his bold theory by removing parts of mice brains and injecting them with what the MIT

magazine describes as "slurries of embryonic cells." While it's still too soon to tell whether or not this anti-aging moonshot works, it's certainly provocative.

As outrageous as the idea of replacing brains may seem, the scientist told the *Tech Review* that when he made his pitch to ARPA-H to fund his research with monkeys and other animals, the agency "didn't blink" at the \$110 million he asked for.

If the brain stuff isn't wild enough, Hébert has also advocated for so-called "full-body replacement" — attaching your head to a youthful body, basically — and suggested that embryonic cells from fetuses could be used in future anti-aging technologies.

Alongside his study into the brains of mice and monkeys, the 58-year-old scientist told the magazine that his personal work is focused on the neocortex, the Udon-noodle-looking exterior part of the brain that hosts our memories and senses.

To him, the neocortex is "arguably the most important part of who we are as individuals." To study it, Hébert has been studying the brains of aborted human fetuses between five and eight weeks of age, which could easily become a politicized issue à la the [stem cell debate](#) of the 2000s should right-wingers get hip to this government-funded scientist's work.

"What we're engineering is a fetal-like neocortical tissue that has all the cell types and structure needed to develop into normal tissue on its own," he said of the research, which has been funded in part by a New York State grant and also by a "brain engineering" startup called BE Therapeutics.

With his hiring at ARPA-H necessitating the closure of his lab at the Albert Einstein campus, Hébert isn't sure what the future of the more controversial side of his work will entail, but he's optimistic regardless.

"We're, you know, a couple steps away from reversing brain aging," he told the *Tech Review*. "A couple of big steps away, I should say."

In a study involving zebrafish, a team of scientists led by the [University College London](#) (UCL) has explored how the brain manages synaptic connections during [sleep](#).

The experts found that the brain weakens new neural connections that were forged during waking hours, but this process only accounts for the first few hours of sleep.

Function of sleep is still unclear

"Although sleep is conserved across the animal kingdom, the precise functions of sleep remain unclear. As sleep deprivation leads to acute impairment of cognitive performance, many theories posit that synaptic plasticity associated with learning and memory preferentially occurs during sleep," wrote the study authors.

"For example, the synaptic homeostasis hypothesis (SHY) proposes that synaptic potentiation during wakefulness results in an ultimately unsustainable increase in synaptic strength and number that must be renormalized during sleep through synaptic weakening and pruning. Such sleep-dependent renormalization has been postulated to broadly affect most excitatory synapses throughout the brain."

The synaptic homeostasis hypothesis

The findings support the synaptic homeostasis hypothesis, positing that [sleep](#) functions as a crucial reset mechanism for the brain, ensuring energy sustainability and readiness for new learning.

"Some studies examining either large neuronal populations or small patches of dendrites have found evidence consistent with the synaptic homeostasis hypothesis, but whether sleep merely functions as a permissive state or actively

promotes synaptic downregulation at the scale of whole neurons is unclear," wrote the researchers.

The brain goes offline

"When we are awake, the connections between brain cells get stronger and more complex. If this activity were to continue unabated, it would be energetically unsustainable," said senior author Jason Rihel, a professor in the UCL Cell & Developmental Biology department.

"Too many active connections between [brain cells](#) could prevent new connections from being made the following day. While the function of sleep remains mysterious, it may be serving as an 'offline' period when those connections can be weakened across the brain, in preparation for us to learn new things the following day."

Synaptic connections in the brain during sleep

The researchers used optically translucent [zebrafish](#) with genes that allow for easy imaging of synapses - the structures enabling communication between brain cells.

"To examine the scope and selectivity of sleep-linked synaptic plasticity, it is vital to comprehensively track the synaptic changes of individual neurons through sleep-wake states," wrote the study authors.

"To that end, we used in vivo synaptic labeling tools in larval zebrafish to image the same neurons and their synapses repeatedly over long timescales, enabling us to map single-neuron synapse changes across sleep and wake states."

Significant changes in the first half of the night

By observing these fish over multiple sleep-wake cycles, they discovered that synaptic connections increase during wakefulness and decrease during sleep,

particularly when sleep was postponed, indicating that sleep pressure intensifies this reduction.

The study revealed that the significant synaptic changes primarily occur during the first half of the night, coinciding with the peak period of slow-wave activity, a critical phase of the sleep cycle.

Sleep dampens connections in the brain

"Our findings add weight to the theory that sleep serves to dampen connections within the brain, preparing for more learning and new connections again the next day," said lead author Anya Suppermpool from UCL Cell & Developmental Biology and UCL Ear Institute.

"But our study doesn't tell us anything about what happens in the second half of the night. There are other theories around sleep being a time for clearance of waste in the brain, or repair for damaged cells – perhaps other functions kick in for the second half of the night."

This research not only deepens our understanding of sleep's role in synaptic management but also poses new questions about the functions of its later stages, paving the way for future investigations into the full spectrum of sleep's impact on [brain health](#).

The study is published in the journal [Nature](#).

Cannabis & Your Brain: The Good and Bad, According to Researchers

Are you curious about how cannabis affects your brain? With the increasing legalization and popularity of marijuana, it's crucial to understand its potential long-term impacts on mental health and cognitive function.

Recent studies have shed light on the complex relationship between cannabis use and brain health, revealing both potential risks and therapeutic applications.

The Endocannabinoid System & Brain Development

The human brain contains a vast network of cannabinoid receptors, which are part of the endocannabinoid system. This system plays a crucial role in regulating neurotransmitter release, synaptic plasticity, and neurodevelopment.

Endocannabinoids function as retrograde messengers, preventing the release of neurotransmitters through presynaptic CB1 receptors. However, when exogenous cannabinoids like THC (the primary psychoactive compound in cannabis) are introduced, they can disrupt these delicate processes, potentially leading to cognitive and behavioral abnormalities.[\(ref\)](#)

Studies have shown that the brain is particularly vulnerable to the effects of cannabis during critical periods of development, such as prenatal exposure and adolescence. The endocannabinoid system is highly expressed in areas involved in cognition and behavior during active neurodevelopment.

Heavy and chronic cannabis use during adolescence has been associated with structural and functional changes in the brain, including reduced gray matter volume in regions involved in memory and learning.

Cognitive Impairment & Mental Health Risks

One of the most well-established risks associated with cannabis use is the increased likelihood of developing schizophrenia and other psychotic disorders. The risk appears to be dose-dependent, with higher levels of use correlating with a greater risk of psychosis.[\(ref\)](#)

Additionally, cannabis use has been linked to a higher prevalence of depression, anxiety, and suicidal ideation.

Even in individuals without pre-existing mental health conditions, regular cannabis use can lead to cognitive impairment across various domains, including memory, attention, and decision-making.

While some studies suggest that these deficits may be reversible after a period of abstinence, others indicate that long-term, heavy use may result in persistent cognitive decline. The impact appears greater than that of alcohol or tobacco use.

Potential Therapeutic Applications

Despite the potential risks, there is growing interest in the therapeutic potential of cannabinoids for certain medical conditions. For example, CBD (a non-psychoactive compound in cannabis) has shown promise in treating epilepsy, chronic pain, and anxiety disorders.

However, more research is needed to fully understand the efficacy and safety of medical cannabis, particularly in vulnerable populations such as children and older adults.

The Need for Further Research

While the current body of research provides valuable insights into the effects of cannabis on brain health, many questions remain unanswered. Factors such as the amount of THC, frequency of use, age of first use, and co-use of other substances can all impact the brain differently.

Additionally, the increasing potency of cannabis products and novel delivery methods warrant further investigation into their short and long-term consequences.

Future studies should aim to clarify the impact of these factors on cognitive and mental health outcomes. More research is also needed to explore the potential therapeutic applications of specific cannabinoids and to develop guidelines for safe and effective medical use.

As cannabis legalization continues to expand, it is crucial that healthcare providers, policymakers, and consumers stay informed about the latest scientific findings to make evidence-based decisions about its use.

Fascinating Facts About The Human Brain

The human brain is the ultimate marvel of nature. Often described as the universe's most complex entity, it orchestrates every facet of our existence, from our thoughts and emotions to our actions and dreams.

As we delve deeper into its enigmatic workings, prepare to be astounded by its abilities, adaptability, and the wonders it unveils within itself. Join us in this exploration of the brain, a captivating voyage into the seat of human intelligence and consciousness. Read on to learn more.

The "Aha!" Moment

Insightful moments, often called "Aha!" moments, are associated with bursts of high-frequency gamma brainwaves.

These moments of sudden understanding involve the integration of information from various brain regions. According to [Scientific American](#), the "increased activity in the anterior superior temporal gyrus of the right hemisphere at the critical moment when the solution appeared..."

100 Billion Neurons

The brain contains about 100 billion neurons, the basic building blocks of the nervous system. Neurons are specialized cells that transmit information through electrical and chemical signals, forming the basis of all brain functions.

According to the [National Institutes of Health](#), "There are approximately 100 billion neurons in a mature human brain. [3] The naturally occurring neuronal cell death occurs prenatally, and elimination of about 50% of unwarranted connections among neurons occurs postnatally."

Music And Emotions

Music activates various areas of the brain, including those responsible for emotion, memory, and movement. According to the [Kennedy Center](#), "Three main areas of the brain are responsible for these emotional responses: nucleus accumbens, amygdala, and the cerebellum."

This explains why music can evoke strong emotions and memories.

An Internal, Or Master Clock

The brain has an internal, or master, clock, allowing us to perceive the passage of time. The brain regions like the suprachiasmatic nucleus help regulate our circadian rhythms and help people sense time intervals.

According to the [National Institute of General Medical Sciences](#), "A master clock in the brain coordinates all the biological clocks in a living thing, keeping the clocks in sync. In vertebrate animals, including humans, the master clock is a group of about 20,000 nerve cells (neurons) that form a structure called the suprachiasmatic nucleus, or SCN."

The Brain Consumes A Lot Of Energy

Despite its size, the brain consumes about 20% of the body's total energy. The brain requires a substantial amount of energy to support its numerous functions, including thinking, learning, and controlling bodily processes.

According to [The Conversation](#), "The brain accounts for about 20% of the body's energy consumption, despite only representing 2% of its weight. That's around 0.3 kilowatt hours (kWh) per day for an average adult, more than 100 times what the typical smartphone requires daily."

An Enormous Storage Center

The human brain is estimated to have the capacity to store 2.5 petabytes of information, equivalent to over 1 million gigabytes. This enormous storage capacity allows us to remember a vast amount of information over our lifetime.

According to [Medanta](#), "The memory capacity of a human brain was testified to have equal to 2.5 petabytes of memory capacity. A "petabyte" means 1024 terabytes or a million gigabytes so that the average adult human brain can accumulate the equivalent of 2.5 million gigabytes of memory."

Creative Thinking

Creativity involves the interaction of multiple brain regions, including those responsible for imagination, memory, and problem-solving. Exploring the neural basis of creativity can inspire innovative thinking and artistic expression.

According to the National Institute of Health, "The hippocampus—as part of the medial temporal lobe subsystem of the default network—supports the generation of creative ideas."

20% Of The Body's Blood Supply

The brain receives about 20% of the body's blood supply, ensuring a constant oxygen and nutrient supply. Adequate blood flow is vital for the brain's energy needs and overall functioning.

[UMass Chan Medical School](#) says, "The brain derives its arterial supply from the paired carotid and vertebral arteries. Every minute, about 600-700 ml of blood flow through the carotid arteries and their branches while about 100-200 ml flow through the vertebral-basilar system."

Ear And The Amygdala

Fear responses are controlled by the amygdala, a small almond-shaped structure in the brain. The amygdala helps us respond to threats, but overactivity can lead to anxiety disorders and phobias.

According to the [Cleveland Clinic](#), "Fear is the main emotion that the amygdala is known to control. That's why your amygdala is so important to survival. It processes things you see or hear and uses that input to learn what's dangerous."

The Brain Is Very Fatty

The brain is composed of about 60% fat, which is essential for insulation and protection. Fat provides a cushion for delicate neural tissue and supports the rapid transmission of electrical signals.

According to the National Institutes of Health, "The human brain is nearly 60 percent fat. We've learned in recent years that fatty acids are among the most crucial molecules that determine your brain's integrity and ability to perform."

Natural Painkillers

The brain can release natural painkillers, like endorphins, to dampen pain signals. This phenomenon has been observed in situations like the "runner's high" during intense exercise.

According to [Harvard Health](#), "Endorphins are released by the hypothalamus and pituitary gland in response to pain or stress, this group of peptide hormones both relieves pain and creates a general feeling of well-being."

Gray Matter Vs. White Matter

The brain has gray matter (neuron cell bodies) on the outside and white matter (nerve fibers) on the inside. Gray matter is involved in processing information, while white matter connects different brain regions.

According to [My-MS](#), "The gray matter is the areas where the actual "processing" is done, whereas the white matter provides the communication between different gray matter areas and between the gray matter and the rest of the body."

Short-Term Memory

Short-term memory typically holds information for about 15-30 seconds and has a limited capacity of around seven items, according to [VeryWell Mind](#).

Short-term memory is crucial for tasks like mental arithmetic and following instructions.

Decision-Making And Self Control

The prefrontal cortex is responsible for executive functions like decision-making, planning, and self-control. Damage or underdevelopment of this area can lead to impulsivity and poor decision-making.

According to [Penn Today](#), "The human brain is organized into circuits that develop from childhood through adulthood to support executive function—

critical behaviors like self-control, decision making, and complex thought. These circuits are anchored by white matter pathways which coordinate the brain activity necessary for cognition."

The Brain Regulates Hunger

The hypothalamus regulates hunger and satiety, making it a crucial part of our appetite control system. Hormones like leptin and ghrelin communicate with the hypothalamus to signal when to eat and when to stop.

[Northwestern Medicine](#) states, "The hypothalamus is the portion of your brain that controls hunger, and the hormone cortisol, which can create hunger cues. When you eat, your stomach expands. This signal notifies the hypothalamus that it's time to stop eating."

The Brain Consumer 20% Of Total Body Oxygen

Even though the brain is only 2% of the human body's total weight, it consumes a lot of oxygen.

According to the National Institutes of Health, "With the average human brain weighing 1400 g (~2% of total body weight), it, therefore, consumes ~49 ml O₂ per minute, or 20% of total body oxygen consumed while at rest. Within the brain, oxygen consumption is highly dynamic and region-specific."

Scents Triggering Memories

The olfactory bulb, responsible for processing scents, is closely connected to the brain's limbic system, which deals with emotions and memories. This connection explains why scents can trigger strong emotional memories.

[Discovery](#) states, "Scents bypass the thalamus and go straight to the brain's smell center, known as the olfactory bulb. The olfactory bulb is directly connected to the amygdala and hippocampus, which might explain why the smell of something can so immediately trigger a detailed memory or even intense emotion."

The Regions That Allow Us To Feel Empathy

Specialized brain regions, such as the temporoparietal junction and the anterior insular cortex, are involved in understanding social interactions and empathy. These regions allow us to navigate complex social dynamics and respond to others' emotions.

According to [Mount Sinai](#), "In the past decade, scientists have used powerful functional MRI imaging to identify several regions in the brain that are associated with empathy for pain. This most recent study, however, firmly establishes that the anterior insular cortex is where the feeling of empathy originates."

Not Seeing Things That Are In Plain Sight

The brain has limited attentional resources, which can result in inattention blindness, where we miss things in plain sight.

[Simply Psychology](#) states, "Because our attentional and processing resources are limited, our brain dedicates them to what fits into our schemas, or our cognitive representations of the world. Thus, when an unexpected stimulus comes into our line of sight, we might not be able to process it on the conscious level."

Maintaining Balance

The cerebellum, located at the back of the brain, plays a crucial role in balance and coordination. The cerebellum fine-tunes movements and helps us maintain balance and posture.

According to [UTHealth Houston](#), "The cerebellum is important for making postural adjustments in order to maintain balance. Through its input from vestibular receptors and proprioceptors, it modulates commands to motor neurons to compensate for shifts in body position or changes in load upon muscles."

Gut-Brain Axis Linked To Mental Health

The gut and the brain are connected through the gut-brain axis, influencing mood and mental health. Emerging research suggests that a healthy gut can positively impact brain function and emotional well-being.

According to [Frontiers](#), "The bidirectional microbiota-gut-brain axis links stress to depression: the percept of stress shapes the microbiota via the efferent brain-gut axis, and the gut microbiota consequently modulates neural circuits via the afferent gut-brain axis."

Blood-Brain Barrier Is Very Important

The blood-brain barrier is a protective system that filters out harmful substances from entering the brain. This barrier helps maintain a stable environment for neural function and protects the brain from toxins.

According to Cleveland Clinic, "Your blood-brain barrier (BBB) is a tightly locked layer of cells that defend your brain from harmful substances, germs and other things that could cause damage. It's a key part of maintaining your brain health. It also holds good things inside your brain, maintaining the organ's delicate chemical balance."

Hemispheric Dominance

While both brain hemispheres work together, some tasks tend to be more associated with one hemisphere than the other. Hemispheric dominance can vary among individuals, impacting their strengths and abilities.

According to [Medical News Today](#), "Hemispheric dominance, also known as lateralization of brain function, describes the tendency for either the left or the right side of the brain to carry out specific brain activities. Even though both sides of the brain are almost identical, one hemisphere primarily carries out some functions over others."

Quick Reflexes And Nerve Impulses

Nerve impulses can travel through the brain at speeds of up to 120 meters per second (268 miles per hour), depending on the body part. This rapid communication allows for quick reflexes and efficient information processing.

According to [BBC Science Focus](#), "Nerve impulses travel at about 50 to 60 metres per second in your arm, which means they can go from your fingertip to your brain, and back again, in about 27 milliseconds. But in most situations, that nerve impulse also has to be processed by the brain so that you can decide on the appropriate muscle movements to react to the sensory input. This can add another 130 to 160 milliseconds to your reaction time.

The Areas Crucial For Language Production

Broca's area and Wernicke's area are crucial for language production and comprehension, respectively. The Wernicke's area is located in the posterior superior temporal lobe and is connected to the Broca's area via a neural pathway.

Damage to these areas can lead to language disorders like Broca's aphasia and Wernicke's aphasia.

The Function Of Mirror Neurons

Mirror neurons fire both when we perform an action and when we observe someone else doing the same action. These neurons are believed to play a role in empathy, imitation, and understanding the intentions of others.

According to the National Institutes of Health, "Essentially, mirror neurons respond to actions that we observe in others. The interesting part is that mirror neurons fire in the same way when we actually recreate that action ourselves. Apart from imitation, they are responsible for a myriad of other sophisticated human behavior and thought processes."

A Brain's Surface Area Is Quite Large

The brain might only be two pounds, but its surface area is actually quite large. The brain's wrinkles and folds, called sulci and gyri, increase its surface area. If flattened out, it would cover the size of a pillowcase.

According to [HowStuffWorks](#), "The cortex dominates the exterior surface of the brain. The surface area of the brain is about 233 to 465 square inches (1,500 to 2,000 cm²), which is about the size of one to two pages of a newspaper."

There Is Still Much To Learn About Resting-State

Even at rest, the brain remains active, with ongoing neural processes like memory consolidation and self-reflection.

Resting-state brain activity is essential for maintaining cognitive health, but there is still much to learn about it.

The Mystery Of Dreaming

©Getty Images/Unsplash

The exact purpose of dreaming remains a mystery, but it's believed to play a role in memory consolidation and emotional processing.

Dreams can be vivid and bizarre, reflecting the brain's creative abilities during sleep.

From conveying precise instruction to evoking entire new worlds, [words and their meanings](#) are central to our existence as humans. But how the multitude of cells making up a human brain take abstract noises or symbols and convert them into something with meaning has long been a mystery. New techniques that can track brain activity down to a single neuron are now revealing exactly where this sound translation takes place within our minds.

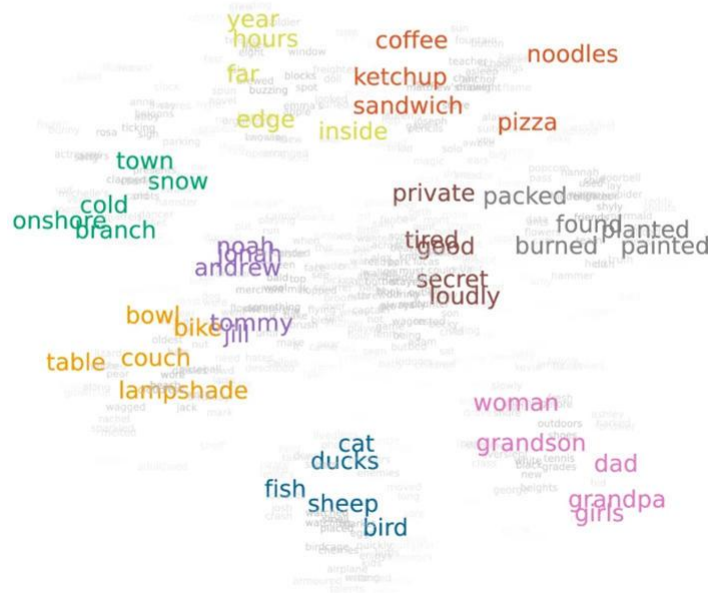
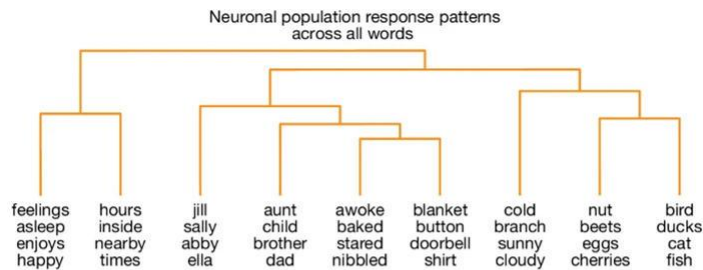
"Humans possess an exceptional ability to extract nuanced meaning through language – when we listen to speech, we can comprehend the meanings of up to tens of thousands of words and do so seamlessly across remarkably diverse concepts and themes," [says](#) Harvard University neuroscientist Ziv Williams.

"We... wanted to find how humans are able to process such diverse meanings during natural speech and through which we are able to rapidly comprehend the meanings of words across a wide array of sentences, stories, and narratives."

Harvard University neuroscientists Mohsen Jamali and Benjamin Grannan and their colleagues used tungsten 'lab-on-a-chip' [microelectrode arrays](#) and [neuropixels](#) to record brain activity on a cellular level in the [prefrontal cortex](#) of 13 participants while they listened to individual sentences and stories.

It took recording surprisingly few neurons in this part of the brain – one involved in speech formation and working memory – for the researchers to be able to loosely 'mind read' general meanings in the patterns of cellular activity.

The recordings revealed words that share similar meanings like noodles and pizza create similar patterns of activity within participants' brains and that these patterns differ substantially when hearing words that have disparate meanings such as duck and [coffee](#).



Words with similar meanings activate specific patterns of neurons in our brains. (Jamali et al., Nature , 2024)
© Provided by ScienceAlert

"We found that while certain neurons preferentially activated when people heard words such as ran or jumped, which reflect actions, other neurons preferentially activated when hearing words that have emotional connotations, such as happy or sad," [explains](#) Williams.

"When looking at all of the neurons together, we could start building a detailed picture of how word meanings are represented in the brain."

What's more, the patterns of neuron activity in response to a word sound depends on what came before and after too.

"Rather than simply responding to words as fixed stored memory representations, these neurons seemed to adaptively represent word meanings in a context-dependent manner during natural speech processing," the team [writes in their paper](#).

This is what allows us to distinguish between homophones – words that sound the same but have different meanings like 'I' and 'eye'.

The researchers also identified hints of the hierarchies that would allow us to rapidly shift through words with similar meanings as we hear them.

"By being able to decode word meaning from the activities of small numbers of brain cells, it may be possible to predict, with a certain degree of granularity, what someone is listening to or thinking," [says](#) Williams.

"It could also potentially allow us to develop brain-machine interfaces in the future that can enable individuals with conditions such as motor paralysis or stroke to communicate more effectively."

The researchers are now keen to explore if the meaning maps they've discovered in our brains remain similar in response [to written words](#), pictures or even different languages, as well as what other parts of the brain may be involved.

This research was published in [Nature](#).

Remote brain manipulation is now possible

South Korean researchers have developed an innovative technology capable of controlling the deep neural circuits of the brain using magnetic fields. Named Nano-MIND (Magnetogenetic Interface for NeuroDynamics), this technology allows for the modulation of complex behaviors such as appetite and sociability, paving the way for major advances in understanding the brain and treating neurological disorders.

The human brain, composed of over 100 billion neurons, remains one of the most mysterious and complex organs to study. To unlock the secrets of advanced brain functions such as cognition and emotions, researchers have long sought to precisely manipulate neuronal circuits. Traditionally, this manipulation relied on invasive methods, often requiring the implantation of devices inside the brain. However, the new technology developed by researchers from the Institute for Basic Science (IBS) and Yonsei University in South Korea promises to revolutionize this field.

Nano-MIND utilizes magnetic fields combined with magnetized nanoparticles to selectively activate or inhibit specific neurons, without the need for implanted devices.

The key to this technique lies in the selective expression of specific receptors, called magnetoreceptors, in the targeted neurons. These receptors respond to a rotating magnetic field, allowing for precise activation or inhibition of neuronal circuits, remotely and wirelessly.

In experiments, researchers succeeded in controlling the appetite of mice by targeting the neural circuits of the lateral hypothalamus. Activation of inhibitory neurons in this region doubled the mice's appetite, while activation of excitatory neurons halved it. Furthermore, by modifying neuronal activity in the medial preoptic area, researchers were able to induce maternal behaviors in non-mother mice, demonstrating the potential of Nano-MIND to influence complex behaviors.

Jinwoo Cheon, director of the Center for Nanomedicine at IBS, emphasizes that this technology, the first of its kind to enable such precise brain control via magnetic fields, could transform neuroscience research. It might also have applications in the development of artificial neural networks and new brain-computer interfaces, while opening up prospects for the treatment of various neurological disorders.



— picture alliance/picture alliance/Getty Images© Provided by Inverse

Electroencephalography, or EEG, was [invented 100 years ago](#). In the years since the invention of this device to monitor brain electricity, it has had an [incredible impact](#) on how scientists study the human brain.

Since its first use, the EEG has shaped researchers' understanding of cognition, from perception to memory. It has also been important for diagnosing and guiding the treatment of multiple brain disorders, including epilepsy.

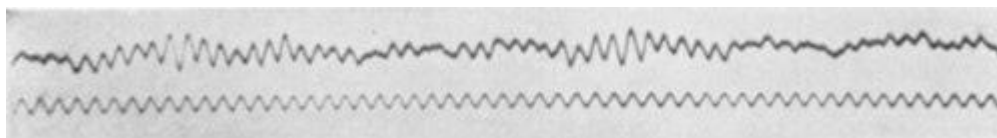
I am a [cognitive neuroscientist](#) who uses EEG to study how people remember events from their past. The EEG's 100-year anniversary is an opportunity to reflect on this discovery's significance in neuroscience and medicine.

Discovery of EEG

On July 6, 1924, psychiatrist Hans Berger performed the [first EEG recording on a human](#), a 17-year-old boy undergoing neurosurgery. At the time, Berger and other researchers were performing electrical recordings on the brains of animals.

What set Berger apart was his obsession with finding the [physical basis of what he called psychic energy](#), or mental effort, in people. Through a series of experiments spanning his early career, Berger measured brain volume and temperature to study changes in mental processes such as intellectual work, attention, and desire.

He then turned to recording electrical activity. Though he recorded the first traces of EEG in the human brain in 1924, he did not [publish the results until 1929](#). Those five intervening years were a tortuous phase of self-doubt about the source of the EEG signal in the brain and refining the experimental setup. Berger recorded hundreds of EEGs on multiple subjects, including his own children, with both experimental successes and setbacks.



This Relatively Simple Device Completely Transformed Neuroscience© Provided by Inverse

Finally convinced of his results, he published a series of papers in the journal [Archiv für Psychiatrie](#) and had hopes of winning a Nobel Prize. Unfortunately, the research community doubted his results, and years passed before anyone else started using EEG in their own research.

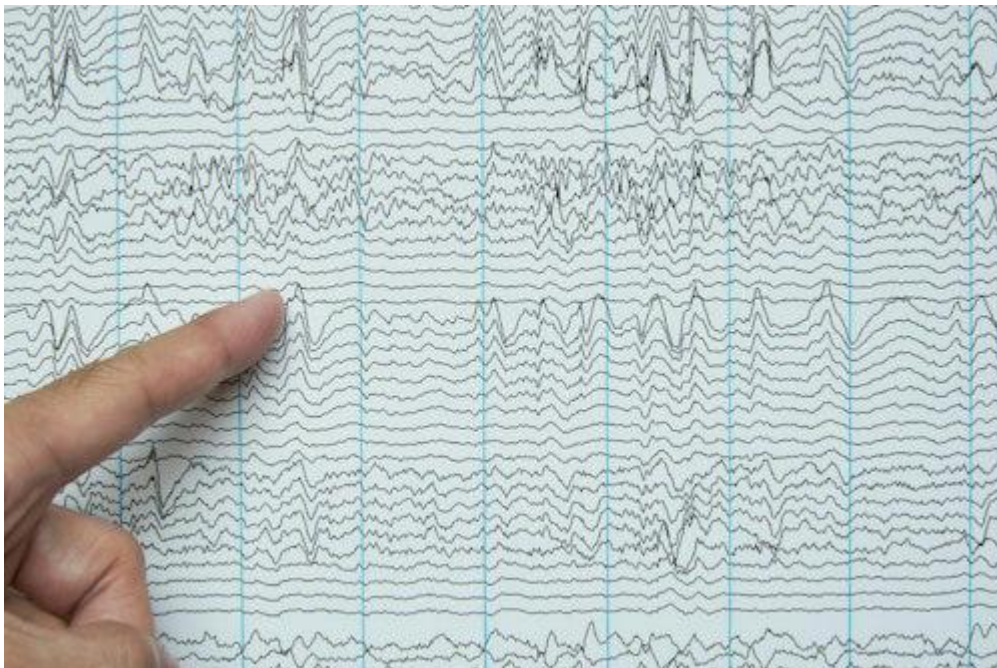
Berger was eventually nominated for a Nobel Prize in 1940. However, Nobles were **not awarded that year** in any category due to World War II and Germany's occupation of Norway.

Neural oscillations

When many neurons are active at the same time, they **produce an electrical signal** strong enough to spread instantaneously through the conductive tissue of the brain, skull, and scalp. EEG electrodes placed on the head can record these electrical signals.

Since the discovery of EEG, researchers have shown that neural activity oscillates at specific frequencies. In his initial EEG recordings in 1924, Berger noted the predominance of oscillatory activity that cycled eight to 12 times per second, or 8 to 12 hertz, named **alpha oscillations**. Since the discovery of alpha rhythms, there have been many attempts to understand how and why neurons oscillate.

Neural oscillations are thought to be important for effective communication between specialized brain regions. For example, theta oscillations that cycle at 4 to 8 hertz are important for communication between brain regions **involved in memory encoding and retrieval** in animals and humans.



Researchers then examined whether they could alter neural oscillations and, therefore, affect how neurons talk to each other. Studies have shown that many behavioral and noninvasive methods can alter neural oscillations and lead to changes in cognitive performance. Engaging in specific mental activities can induce neural oscillations in the frequencies those mental activities use. For example, my team's research found that [mindfulness meditation can increase theta frequency](#) oscillations and improve memory retrieval.

Noninvasive brain stimulation methods can target frequencies of interest. For example, my team's ongoing research found that brain stimulation at theta frequency can [lead to improved memory retrieval](#).

EEG has also led to major discoveries about how the brain processes information in [many other cognitive domains](#), including how people perceive the world around them, how they focus their attention, how they communicate through language, and how they process emotions.

Diagnosing and treating brain disorders

EEG is commonly used today to diagnose [sleep disorders and epilepsy](#) and to guide [brain disorder treatments](#).

Scientists are using EEG to see whether memory can be improved with noninvasive brain stimulation. Although the research is still in its infancy, there have been some promising results. For example, one study found that noninvasive brain stimulation at gamma frequency – 25 hertz – improved [memory and neurotransmitter transmission in Alzheimer's disease](#).

A new type of noninvasive brain stimulation called [temporal interference](#) uses two high frequencies to cause neural activity equal to the difference between the stimulation frequencies. The high frequencies can better penetrate the brain and reach the targeted area. Researchers recently tested this method in people using 2,000 hertz and 2,005 hertz to send 5-hertz theta frequency at a key brain region for memory, the hippocampus. This led to improvements in [remembering the name associated with a face](#).

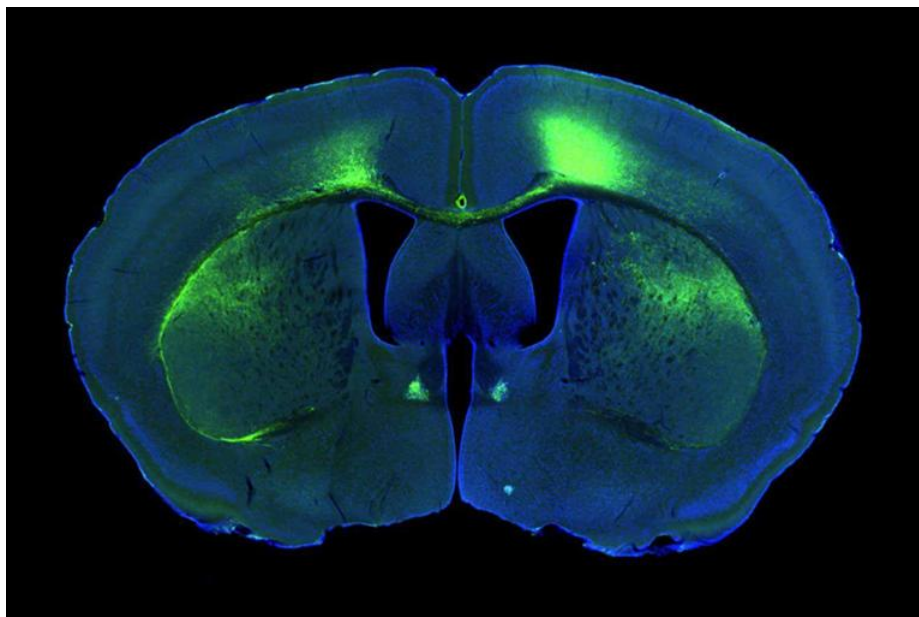
Although these results are promising, more research is needed to understand the exact role neural oscillations play in cognition and whether altering them can lead to long-lasting cognitive enhancement.

The future of EEG

The 100-year anniversary of the EEG provides an opportunity to consider what it has taught us about brain function and what this technique can do in the future.

In a survey commissioned by the journal Nature Human Behaviour, over 500 researchers who use EEG in their work were asked to make predictions on the future of the technique. What will be possible in the next 100 years of EEG?

Some researchers, including myself, predict that we'll use EEG to diagnose and create targeted treatments for brain disorders. Others anticipate that an [affordable, wearable EEG](#) will be widely used to enhance cognitive function at home or will be seamlessly [integrated into virtual reality](#) applications. The possibilities are vast.



A micrograph of a section through a mouse's brain highlighting neural pathways (green) MARK AND MARY STEVENS
NEUROIMAGING AND INFORMATICS INSTITUTE/SCIENCE PHOTO LIBRARY© Provided by New Scientist

Analysing a mouse's brain activity tells scientists where the animal is located and the exact direction it is looking. With further research, the findings could one day help robots navigate autonomously.

Mammalian [brains](#) use two main types of neurons for navigation: "head direction cells" show where an animal is facing and "grid cells" help provide a two-dimensional brain map of where it is located.

To learn more about the firing of these neurons, [Vasileios Maroulas](#) at the University of Tennessee, Knoxville, and his colleagues - together with the US Army Research Laboratory - analysed data from a previous study.

In this experiment, probes were inserted into several mice's brains. Data on their neural firing patterns were then paired with video footage showing their locations and head positions as they moved around an open environment.

From this, Maroulas and his colleagues developed an [artificial intelligence](#) algorithm that can work out where a mouse is looking and where it is located.

In effect, it is like the drop pin and directional arrow on a smartphone's map app, except instead of connecting to a GPS satellite, scientists analyse a subject's brain activity.

"This method allows us to not be dependent on a preloaded map or updating the GPS coordinates based on, say, satellite data," says Maroulas. "In some sense, the algorithm 'thinks' and recognises space as a mammalian brain would."

Free will: Can neuroscience reveal if your choices are yours to make?

The AI could eventually enable intelligent systems to navigate autonomously, he says. "In other words, we take advantage of how the mammalian brain processes data and incorporate it in the architecture of the algorithm."

[Adam Hines](#) at the Queensland University of Technology in Australia says the smartphone app analogy is a helpful one. "You have positional information (the drop pin) aligned with direction (blue arrow) and during navigation, the two are constantly updating as you move. Grid cells are like the GPS and heading cells are like a compass."

Journal reference:

Biophysical Journal DOI: [10.1016/j.bpj.2024.01.025](https://doi.org/10.1016/j.bpj.2024.01.025)

Neural network learning techniques stem from the dynamics of the brain.

However, these two scenarios, brain learning and deep learning, are intrinsically different. One of the most prominent differences is the number of layers each one possesses.

Deep learning architectures typically consist of numerous layers that can be increased to hundreds, enabling efficient learning of complex classification tasks. Contrastingly, the brain consists of very few layers, yet despite its shallow architecture and noisy and slow dynamics, it can efficiently perform complex classification tasks.

The critical question driving new research is the possible mechanism underlying the brain's efficient shallow learning, enabling it to perform classification tasks with the same accuracy as deep learning. In an article published in [Physica A: Statistical Mechanics and its Applications](#), researchers from Bar-Ilan University in Israel show how such shallow learning mechanisms can compete with deep learning.

"Instead of a deep architecture, like a skyscraper, the brain consists of a wide shallow architecture, more like a very wide building with only very few floors," said Prof. Ido Kanter of Bar-Ilan's Department of Physics and Gonda (Goldschmied) Multidisciplinary Brain Research Center, who led the research.

"The capability to correctly classify objects increases where the [architecture becomes deeper](#), with more layers. In contrast, the brain's shallow mechanism indicates that a wider network better classifies objects," said Ronit Gross, an undergraduate student and one of the key contributors to this work. "Wider and higher architectures represent two complementary mechanisms," she added.

Nevertheless, the realization of very wide [shallow architectures](#), imitating the [brain's dynamics](#), requires a shift in the properties of advanced GPU technology, which is capable of accelerating deep architecture, but fails in the implementation of wide shallow ones.

More information: Ofek Tevet et al, Efficient shallow learning mechanism as an alternative to deep learning, *Physica A: Statistical Mechanics and its Applications* (2024). DOI: [10.1016/j.physa.2024.129513](https://doi.org/10.1016/j.physa.2024.129513)

Brain-computer interfaces are a groundbreaking technology that can help paralyzed people regain functions they've lost, like moving a hand. These devices record signals from the brain and decipher the user's intended action, bypassing damaged or degraded nerves that would normally transmit those brain signals to control muscles.

[Since 2006](#), demonstrations of brain-computer interfaces in humans have primarily focused on restoring arm and hand movements by enabling people to [control computer cursors](#) or [robotic arms](#). Recently, researchers have begun developing [speech brain-computer interfaces](#) to restore communication for people who cannot speak.

As the user attempts to talk, these brain-computer interfaces record the person's unique brain signals associated with attempted muscle movements for speaking and then translate them into words. These words can then be displayed as text on a screen or spoken aloud using text-to-speech software.

I'm a [researcher](#) in the [Neuroprosthetics Lab](#) at the University of California, Davis, which is part of the [BrainGate2](#) clinical trial. My colleagues and I recently demonstrated a speech brain-computer interface that [deciphers the attempted speech of a man with ALS](#), or amyotrophic lateral sclerosis, also known as Lou Gehrig's disease. The interface converts neural signals into text with over 97

percent accuracy. Key to our system is a set of artificial intelligence language models — artificial neural networks that help interpret natural ones.

Recording brain signals

The first step in our speech-brain-computer interface is recording brain signals. There are several sources of brain signals, some of which require surgery to record. Surgically implanted recording devices can capture high-quality brain signals because they are placed closer to neurons, resulting in stronger signals with less interference. These neural recording devices include grids of electrodes placed on the brain's surface or electrodes implanted directly into brain tissue.

In our study, we used electrode arrays surgically placed in the speech motor cortex, the part of the brain that controls muscles related to speech, of the participant, Casey Harrell. We recorded neural activity from 256 electrodes as Harrell attempted to speak.



Brain-Computer Interfaces Could Get A Significant Boost From AI

Decoding brain signals

The next challenge is relating the complex brain signals to the words the user is trying to say.

One approach is to map neural activity patterns directly to spoken words. This method requires recording brain signals corresponding to each word multiple

times to identify the average relationship between neural activity and specific words. While this strategy works well for small vocabularies, as demonstrated in a [2021 study with a 50-word vocabulary](#), it becomes impractical for larger ones. Imagine asking the brain-computer interface user to try to say every word in the dictionary multiple times — it could take months, and it still wouldn't work for new words.

Instead, we use an alternative strategy: mapping brain signals to phonemes, the basic units of sound that make up words. In English, there are 39 phonemes, including ch, er, oo, pl, and sh, that can be combined to form any word. We can measure the neural activity associated with every phoneme multiple times just by asking the participant to read a few sentences aloud. By accurately mapping neural activity to phonemes, we can assemble them into any English word, even ones the system wasn't explicitly trained with.

To map brain signals to phonemes, we use advanced machine learning models. These models are particularly well-suited for this task due to their ability to find patterns in large amounts of complex data that would be impossible for humans to discern. Think of these models as super-smart listeners who can pick out important information from noisy brain signals, much like you might focus on a conversation in a crowded room. Using these models, we were able to decipher phoneme sequences during attempted speech with over 90% accuracy.

From phonemes to words

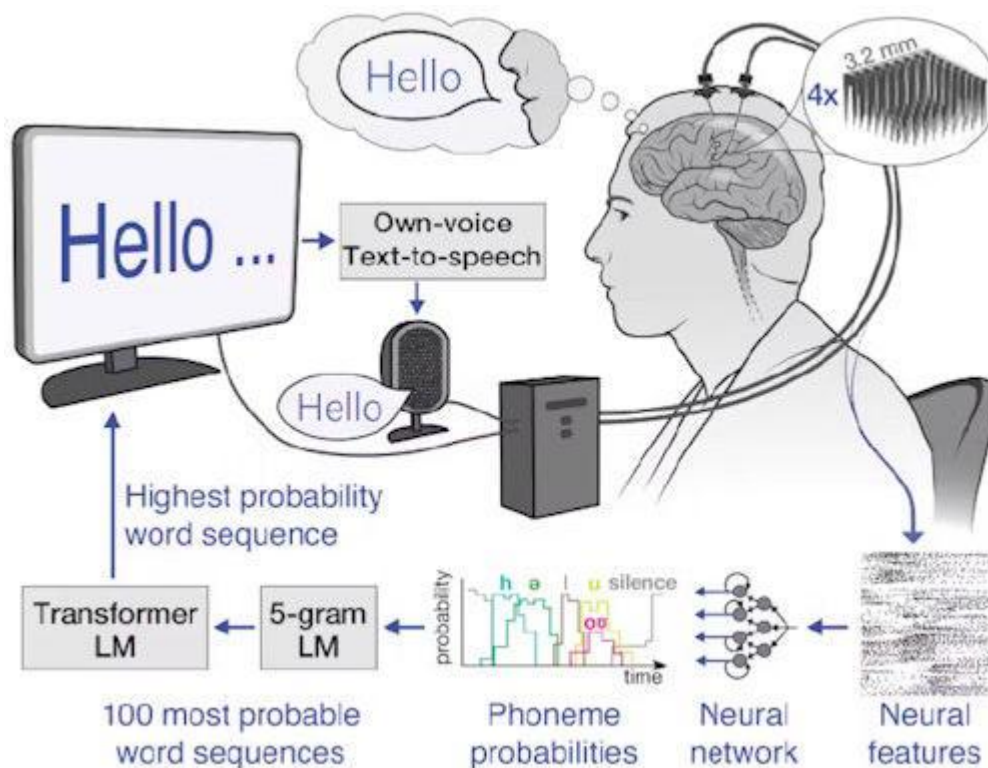
Once we have the deciphered phoneme sequences, we need to convert them into words and sentences. This is challenging, especially if the deciphered phoneme sequence isn't perfectly accurate. To solve this puzzle, we use two complementary types of machine-learning language models.

The first is n-gram language models, which predict which word is most likely to follow a set of n words. We trained a 5-gram, or five-word, language model on [millions of sentences](#) to predict the likelihood of a word based on the previous four words, capturing local context and common phrases. For example, after "I am very good," it might suggest "today" as more likely than "potato."

Using this model, we convert our phoneme sequences into the 100 most likely word sequences, each with an associated probability.

The second is large language models, which power AI chatbots and also predict which words most likely follow others. We use large language models to refine our choices. These models, trained on vast amounts of diverse text, have a broader understanding of language structure and meaning. They help us determine which of our 100 candidate sentences makes the most sense in a wider context.

By carefully balancing probabilities from the n-gram model, the large language model, and our initial phoneme predictions, we can make a highly educated guess about what the brain-computer interface user is trying to say. This multi-step process allows us to handle the uncertainties in phoneme decoding and produce coherent, contextually appropriate sentences.



Brain-Computer Interfaces Could Get A Significant Boost From AI

Real-world benefits

In practice, this speech-decoding strategy has been remarkably successful. We've enabled Casey Harrell, a man with ALS, to "speak" with over 97 percent accuracy using just his thoughts. This breakthrough allows him to easily converse with his family and friends for the first time in years, all in the comfort of his own home.

Speech brain-computer interfaces represent a significant step forward in restoring communication. As we continue to refine these devices, they hold the promise of giving a voice to those who have lost the ability to speak, reconnecting them with their loved ones and the world around them.

However, challenges remain, such as making the technology more accessible, portable, and durable over years of use. Despite these hurdles, speech-brain-computer interfaces are a powerful example of how science and technology can come together to solve complex problems and dramatically improve people's lives.

This article was originally published on [The Conversation](#) by Nicholas Card at University of California, Davis.

How To Hack Your Own Brain

DOPAMINE

The Reward Chemical

- Completing a task
- Eating food
- Celebrating little wins
- Self-care activities

OXYTOCIN

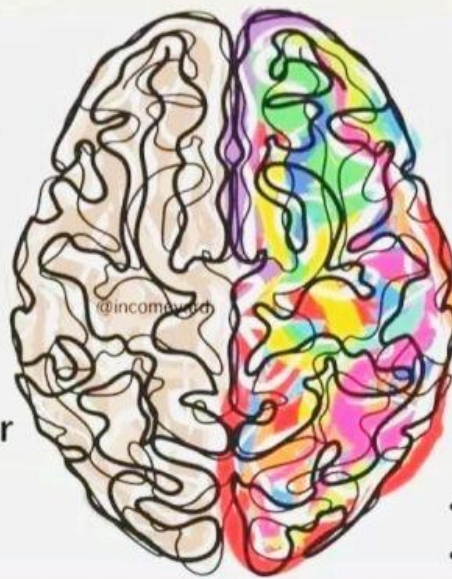
The Love Hormone

- Playing with a baby
- Playing with a dog
- Give a compliment
- Hold hands
- Hug family

SEROTONIN

The Mood Stabilizer

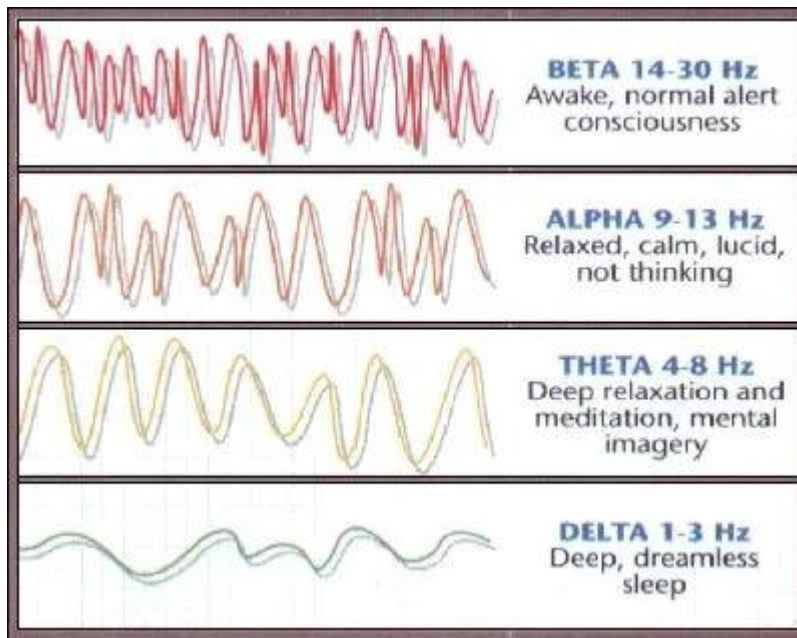
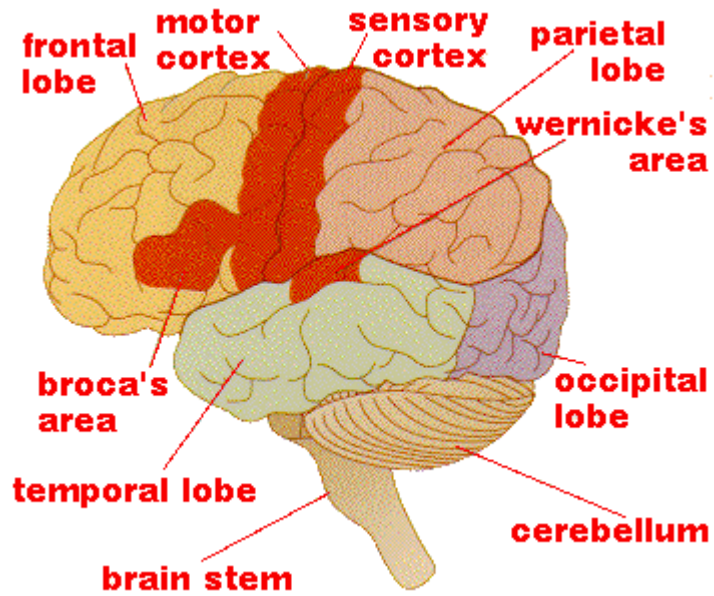
- Praying
- Walking in nature
- Running
- Sun exposure
- Cycling
- Swimming



MELATONIN

The Sleep Hormone

- Dim your lights at night.
- Reducing screen time
- Sun exposure
- Eating right
- Relaxing activities



The Spatial Computing theory posits that beta rhythms act like stencils, dictating where gamma rhythms can encode information in the cortex, for instance from the senses. Credit: MIT Picower Institute© Provided by Medical Xpress

It could be very informative to observe the pixels on your phone under a microscope, but not if your goal is to understand what a whole video on the screen shows. Cognition is much the same kind of emergent property in the brain. It can only be understood by observing how millions of cells act in coordination, argues a trio of MIT neuroscientists. In a new article, they lay out a framework for understanding how thought arises from the coordination of neural activity driven by oscillating electric fields—also known as brain "waves" or "rhythms."

The paper is [published](#) in the journal *Current Opinion in Behavioral Sciences*.

Historically dismissed solely as byproducts of neural activity, brain rhythms are actually critical for organizing it, write Picower Professor Earl Miller and research scientists Scott Brincat and Jefferson Roy. And while neuroscientists have gained tremendous knowledge from studying how individual brain cells connect and how and when they emit "spikes" to send impulses through specific circuits, there is also a need to appreciate and apply new concepts at the brain rhythm scale, which can span individual—or even multiple—brain regions.

"Spiking and anatomy are important but there is more going on in the brain above and beyond that," said senior author Miller, a faculty member in The Picower Institute for Learning and Memory and the Department of Brain and Cognitive Sciences at MIT. "There's a whole lot of functionality taking place at a higher level, especially cognition."

The stakes of studying the brain at that scale, the authors write, might not only include understanding healthy higher-level function but also how those functions become disrupted in disease.

"Many neurological and psychiatric disorders, such as schizophrenia, epilepsy and Parkinson's involve disruption of emergent properties like neural synchrony," they write. "We anticipate that understanding how to interpret and interface with these emergent properties will be critical for developing effective treatments as well as understanding cognition."

The emergence of thoughts

The bridge between the scale of individual neurons and the broader-scale coordination of many cells is founded on electric fields, the researchers write. Via a phenomenon called "ephaptic coupling," the electrical field generated by the activity of a neuron can influence the voltage of neighboring neurons, creating an alignment among them. In this way, electric fields both reflect neural activity but also influence it.

In [a paper in 2022](#), Miller and colleagues showed via experiments and computational modeling that the information encoded in the electric fields generated by ensembles of neurons can be read out more reliably than the information encoded by the spikes of individual cells. In 2023, Miller's lab [provided evidence](#) that rhythmic electrical fields may coordinate memories between regions.

At this larger scale, in which rhythmic electric fields carry information between brain regions, Miller's lab has published numerous studies showing that lower-frequency rhythms in the so-called "beta" band originate in deeper layers of the brain's cortex and [appear to regulate](#) the power of faster-frequency "gamma" rhythms in more superficial layers. By recording neural activity in the brains of animals engaged in working memory games the lab has shown that beta rhythms carry "top down" signals to control when and where gamma rhythms can encode sensory information, such as the images that the animals need to remember in the game.

Some of the lab's latest evidence suggests that beta rhythms apply this control of cognitive processes to physical patches of the cortex, essentially acting like stencils that pattern where and when gamma can encode sensory information into memory, or retrieve it. According to this theory, which Miller calls "[Spatial Computing](#)," beta can thereby establish the general rules of a task (for instance, the back and forth turns required to open a combination lock), even as the specific information content may change (for instance, new numbers when the combination changes).

More generally, this structure also enables neurons to flexibly encode more than one kind of information at a time, the authors write, a widely observed neural

property called "mixed selectivity." For instance, a neuron encoding a number of the lock combination can also be assigned, based on which beta-stenciled patch it is in, the particular step of the unlocking process that the number matters for.

In the new study, Miller, Brincat and Roy suggest another advantage consistent with cognitive control being based on an interplay of large-scale coordinated rhythmic activity: "Subspace coding." This idea postulates that brain rhythms organize the otherwise massive number of possible outcomes that could result from, say, 1,000 neurons engaging in independent spiking activity. Instead of all the many combinatorial possibilities, many fewer "subspaces" of activity actually arise, because neurons are coordinated, rather than independent.

It is as if the spiking of neurons is like a flock of birds coordinating their movements. Different phases and frequencies of brain rhythms provide this coordination, aligned to amplify each other, or offset to prevent interference. For instance, if a piece of sensory information must be remembered, neural activity representing it can be protected from interference when new sensory information is perceived.

"Thus the organization of neural responses into subspaces can both segregate and integrate information," the authors write.

The power of brain rhythms to coordinate and organize information processing in the brain is what enables functional cognition to emerge at that scale, the authors write. Understanding cognition in the brain, therefore, requires studying rhythms.

"Studying individual neural components in isolation—individual neurons and synapses—has made enormous contributions to our understanding of the brain and remains important," the authors conclude. "However, it's becoming increasingly clear that to fully capture the brain's complexity, those components must be analyzed in concert to identify, study, and relate their emergent properties."

More information: Earl K Miller et al, Cognition is an emergent property, *Current Opinion in Behavioral Sciences* (2024). DOI: [10.1016/j.cobeha.2024.101388](https://doi.org/10.1016/j.cobeha.2024.101388)

Provided by Massachusetts Institute of Technology

Most people view sleep and wakefulness as two distinct states, clearly separating our daily activities.

Traditional neuroscience has anchored this perspective, defining sleep by the long, slow waves that traverse our brain. Now, pioneering research has unveiled intriguing details that challenge this belief.

The sleeping brain

The researchers have found that sleep can be detected by neural activity patterns lasting for just milliseconds - 1,000 times shorter than a second.

What's more, they discovered that small areas of the brain could briefly "flicker" [awake](#), while the rest of the brain is asleep, and the opposite can also occur.

These revelations open up fresh avenues to explore and understand the fundamental [brain wave patterns](#) that govern consciousness.

The research is a collaboration between the laboratories of Professor Keith Hengen at [Washington University in St. Louis](#) and Professor David Haussler at [UC Santa Cruz](#), with crucial contributions from Ph.D. students, David Parks (UCSC) and Aidan Schneider (WashU).

What is a state?

Professor Hengen highlighted the significant implications of their discovery. He said that with powerful tools and new computational methods, there's so much to be gained by challenging our most basic assumptions and revisiting the question of "what is a state?"

"Sleep or wake is the single greatest determinant of your behavior, and then everything else falls out from there. So if we don't understand what sleep and wake actually are, it seems like we've missed the boat."

Micro-naps in the brain

Professor Haussler noted that the research revealed different parts of the brain "taking little naps" while other regions remain awake.

"It was surprising to us as scientists to find that different parts of our brains actually take little naps when the rest of the brain is awake. Many people may have already suspected this in their spouse, so perhaps a lack of male-female bias is what is surprising."

Brain activity patterns by the millisecond

In the course of their four-year research, Parks and Schneider trained a neural network to scrutinize patterns within an enormous amount of brain wave data.

Ultimately, the team observed patterns occurring at extremely high frequencies, challenging foundational beliefs about the neurological basis of sleep and wake states.

Studying brain data that lasted for only a millisecond, the researchers found that the model could differentiate between sleep and wake states. This remarkable finding confirmed that the model wasn't relying on the slow-moving waves to learn the difference.

"The previous feeling was that nothing would be found there, that all the relevant information was in the slower frequency waves," said Professor Haussler.

"This paper says if you ignore the conventional measurements and just look at the details of the high-frequency measurement over just a thousandth of a second, there is enough there to tell if the tissue is asleep or not."

According to Professor Haussler, this tells us that there is something going on a very fast scale - that's a new hint to what might be going on in sleep.

Uncovering neural "flickers"

Upon further investigation of these high-speed activity patterns, the researchers discovered another surprising phenomenon, which they refer to as "flickers."

These are instances where, for a split second, one region of the brain would be awake while the rest were asleep, and vice versa.

These flickers don't adhere to the traditional neuroscience rules governing the strict cycle between wake, non-REM sleep, and [REM sleep](#), further defying standard beliefs on sleep dynamics.

The future of sleep research

These groundbreaking findings pave the way for a deeper understanding and potential treatments of neurodevelopmental and neurodegenerative diseases, both of which are closely associated with [sleep dysregulation](#).

The research holds promise for developing new diagnostic tools and therapies that target the specific neural mechanisms involved in these conditions.

"The more we understand fundamentally about what sleep and wake are, the more we can address pertinent clinical and disease-related problems," said Professor Hengen.

This knowledge could revolutionize our approach to treating a wide range of disorders linked to sleep, from insomnia and sleep apnea to more complex neurological conditions such as Alzheimer's and autism.

The study is published in the journal [Nature Neuroscience](#).



Illustration of a synapse. Credit: NIH.© ZME Science

Our memories and thoughts stem from complex patterns of electrical and chemical activity in the brain. Central to this activity are synapses, the junctions where branches of neurons connect, similar to electrical wires. Here, an axon from one neuron links to a dendrite of another. At these synapses, neurotransmitters carry signals across the gap, instructing the receiving neuron to pass on an electrical signal to others. Remarkably, each neuron can form thousands of these connections.

Similar to computers, we measure the brain's memory storage in "bits," and the number of bits it can hold rests on the number and strength of its synapses. It's worth noting that brains are analog — just so you don't get the wrong idea. Brains process everything in parallel, in continuous time rather than in discrete intervals, so the "bit" (the smallest unit of digital data) in this case is not a perfect

analogy for how information is stored in a biological system. Nevertheless, it serves the purpose of estimating information processing.

Previously, it was believed that synapses came in very limited sizes and strengths. However, recent research suggests otherwise. The human brain's capacity to store information is almost ten times greater than previously estimated, according to a new study.

New Insights into Synaptic Strength and Memory Storage

A team of researchers from the University of California, San Diego and the Salk Institute developed a highly precise method to assess the strength of synapses in the brain of a rat. These synapses, where brain cells communicate and store information, play a critical role in learning and memory. By understanding how synapses strengthen and weaken, the scientists precisely quantified the information storage capacity of these connections.

In the human brain, over 100 trillion synapses exist between neurons. These synapses facilitate information transfer across the brain by launching chemical messengers. As we learn, specific synapses strengthen, enabling us to retain new information. This process is known as synaptic plasticity, is essential for memory formation and cognitive function.

When neurons talk, they do so at different volumes — some neurons whisper to each other while others shout. The 'volume' setting of the synapse, or the synaptic strength, is not static, but rather can change in both the short term and long term. Synaptic plasticity refers to these changes in synaptic strength.

However, aging and neurological diseases like Alzheimer's can weaken synapses, reducing our cognitive ability. This is why studies like these are important — they can help scientists unlock new therapies that may stave off or even cure neurodegenerative diseases that currently plague millions of patients across the world. However, measuring the strength of synapses has traditionally been challenging.

The team analyzed pairs of synapses from a rat hippocampus, a brain region vital for learning and memory. The new study's method leverages information theory, which allows scientists to quantify how much information synapses can store and transmit. What this means is that a framework typically reserved for computers was applied to the brain in order to estimate the number of bits that synapses can hold. They found that these pairs of synapses responded to the same type and amount of brain signals, performing synaptic strength adjustment.

Current and Future Potential

Ultimately, this analysis indicated that hippocampal synapses could store between 4.1 and 4.6 bits of information. Scientists thought each synapse could hold one bit. Overall, this means the human brain could store ten times more information than previously thought, or at least a [petabyte](#) — that's as much as 500 billion DVDs or all the movies ever made in high-definition.

While the study focuses on a small part of the rat brain, future research could explore how information storage capacity varies across different brain areas and species. This method could also compare healthy and diseased brain states, offering insights into conditions that affect cognitive functions.

In 2016, the Salk researchers [reached the same conclusions](#). The new findings serve to confirm this initial assessment. Back then, the researchers also made another important revelation: there are at least 26 size categories of synapses, rather than just a few.

These findings also provide insight into the brain's remarkable efficiency. Despite its complexity, the waking adult brain uses only about 20 watts of continuous power, comparable to a very dim light bulb. These discoveries could inspire computer scientists to design highly precise yet energy-efficient computers. These innovations could particularly benefit "deep learning" and artificial neural networks, enhancing their capabilities in areas like speech recognition, object identification, and language translation.

The findings appeared in the journal [Neural Computation](#).

Newly published research from Colorado State University answers

fundamental questions about cellular connectivity in the brain that could be useful in the development of treatments for neurological diseases like autism, epilepsy or schizophrenia.

The work, [highlighted](#) in the *Proceedings of the National Academy of Sciences*, focuses on how neurons in the brain transmit information between each other through highly specialized subcellular structures called synapses. These delicate structures are key to controlling many processes across the nervous system via electrochemical signaling, and pathogenic mutations in the genes that impair their development can cause severe mental disorders.

Despite their important role in linking neurons across different brain regions, the way synapses form and function is still not well understood, said Assistant Professor Soham Chanda.

To answer that fundamental question, Chanda and his team in the Department of Biochemistry and Molecular Biology focused on a specific and important type of synapse called GABAergic. He said neuroscience researchers have long hypothesized that these synapses might form because of a release of GABA and the corresponding sensing activity between two neurons in proximity. However, research in the paper now shows that these synapses can begin to develop autonomously and apart from that neuronal communication, mainly due to the scaffolding action of a protein called Gephyrin. These findings clarify the key mechanisms of synaptic formation, which might allow researchers to further focus on synapse dysfunction and health treatment options.

Chanda's team used human neurons derived from stem cells to develop a model of the brain that could rigorously test these relationships. Using a gene-editing tool called CRISPR-Cas9, they were able to genetically manipulate the system and confirm the role of Gephyrin in the synapse formation process.

"Our study shows that even if a pre-synaptic neuron is not releasing GABA, the post-synaptic neuron can still put together the necessary molecular machineries prepared to sense GABA," Chanda said. "We used a gene-editing tool to remove the Gephyrin protein from neurons, which largely reduced this autonomous assembly of synapses—confirming its important role irrespective of neuronal communication."

Using stem cells to advance understanding of neuron and synapse formation

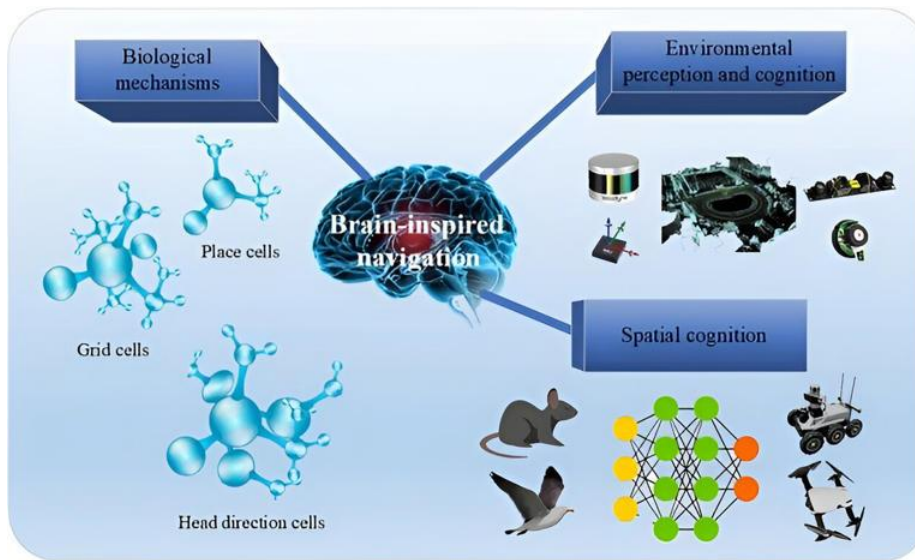
Neuroscientists have traditionally used rodent systems to study these synaptic connections in the brain. While that provides a suitable model, Chanda and his team were interested in testing synapse properties in a human cellular environment that could eventually be more easily translated into treatments.

To achieve this, his team cultivated human stem cells to form brain cells that could mimic the properties of human neurons and synapses. They then conducted extensive high-resolution imaging of these neurons and tracked their electrical activities to understand synaptic mechanisms.

Chanda said that several mutations in the Gephyrin protein have been associated with neurological disorders like epilepsy, which alters neuronal excitability in the human brain. That makes understanding its basic cellular function an important first step towards treatment and prevention.

"Now that we better understand how these synaptic structures interact and organize, the next question will be to elucidate how defects in their relationships can lead to disease and identify the ways one can predict or intervene in that process," he said.

More information: Etta Carricaburu et al, Gephyrin promotes autonomous assembly and synaptic localization of GABAergic postsynaptic components without presynaptic GABA release, *Proceedings of the National Academy of Sciences* (2024). DOI: [10.1073/pnas.2315100121](https://doi.org/10.1073/pnas.2315100121)



The research team at the School of Computer Science and Engineering at Northeastern University uses a variety of sensors to collect environmental data and employs multimodal information fusion to enhance environmental perception. Credit: Yanan Bai, School of Computer Science and Engineering, Northeastern University

In the ever-evolving field of robotics, a groundbreaking approach has emerged, revolutionizing how robots perceive, navigate, and interact with their environments. This new frontier, known as brain-inspired navigation technology, integrates insights from neuroscience into robotics, offering enhanced capabilities and efficiency.

A paper on this topic, "[A Review of Brain-Inspired Cognition and Navigation Technology for Mobile Robots](#)," was published in the journal *Cyborg and Bionic Systems* on June 27, 2024.

Brain-inspired navigation technologies are not just a mere improvement over traditional methods; they represent a paradigm shift. By mimicking the neural mechanisms of animals, these technologies provide robots with the ability to navigate through complex and unknown terrains with unprecedented accuracy and adaptability.

At the heart of this technology lies the concept of spatial cognition, which is central to how animals, including humans, navigate their environments. Spatial cognition involves the brain's ability to organize and interpret spatial data for navigation and memory.

Robots equipped with brain-inspired navigation systems utilize a multi-layered network model that integrates sensory data from multiple sources. This model allows the robot to create a "cognitive map" of its surroundings, much like the neural maps created by the hippocampus in the human brain.

One of the significant advantages of brain-inspired navigation is its robustness in challenging environments. Traditional navigation systems often struggle with dynamic and unpredictable settings, where the reliance on pre-mapped routes and landmarks can lead to failures.

In contrast, brain-inspired systems continuously learn and adapt, improving their navigational strategies over time. This capability is particularly beneficial in environments like disaster zones or extraterrestrial surfaces, where prior mapping is either impossible or impractical.

Moreover, these systems significantly reduce energy consumption and computational needs. By focusing only on essential data and employing efficient neural network models, robots can operate longer and perform more complex tasks without the need for frequent recharging or maintenance.

The technology's applications are vast and varied. For instance, autonomous vehicles equipped with brain-inspired systems could navigate more safely and efficiently, reacting in real-time to sudden changes in traffic conditions or road layouts. Similarly, drones used for delivery services could plan their routes more effectively, avoiding obstacles and optimizing delivery times.

Despite its promising potential, the development of brain-inspired navigation technology faces several challenges. Integrating biological principles into mechanical systems is inherently complex, requiring multidisciplinary efforts from fields such as neuroscience, cognitive science, robotics, and artificial intelligence. Moreover, these systems must be scalable and versatile enough to be customized for different types of robotic platforms and applications.

As researchers continue to unravel the mysteries of the brain's navigational capabilities, the future of robotics looks increasingly intertwined with the principles of neuroscience. The collaboration across disciplines promises not only to advance our understanding of the brain but also to pave the way for a new generation of intelligent robots. These robots will not only assist in mundane

tasks but also perform critical roles in search and rescue operations, planetary exploration, and much more.

In conclusion, brain-inspired navigation technology represents a significant leap forward in robotics, merging the abstract with the applied, the biological with the mechanical, and the theoretical with the practical. As this technology continues to evolve, it will undoubtedly open new horizons for robotic applications, making machines an even more integral part of our daily lives and work.

More information: Yanan Bai et al, A Review of Brain-Inspired Cognition and Navigation Technology for Mobile Robots, *Cyborg and Bionic Systems* (2024). DOI: [10.34133/cbsystems.0128](https://doi.org/10.34133/cbsystems.0128)

Time, long considered a fundamental aspect of our universe, might actually be an illusion stemming from [quantum entanglement](#), according to a new study.

This idea presents a fresh perspective on the longstanding issue physicists face: the inconsistency of time in our best theories of the universe, which hinders the quest for a unified "theory of everything."

Researchers propose that time is a result of quantum entanglement, the mysterious connection between particles separated by vast distances. Their findings, published in the [journal Physical Review A](#), could offer a clue to solving the problem of time.

"There exists a way to introduce time which is consistent with both classical laws and quantum laws, and is a manifestation of entanglement," explained Alessandro Coppo, a physicist at the [National Research Council of Italy](#) and the study's lead author. "The correlation between the clock and the system creates the emergence of time, a fundamental ingredient in our lives."

In [quantum mechanics](#), time is a fixed phenomenon, an unchanging flow from past to present. It remains external to the ever-changing quantum systems it measures and can only be observed through changes in external entities, like the hands of a clock.

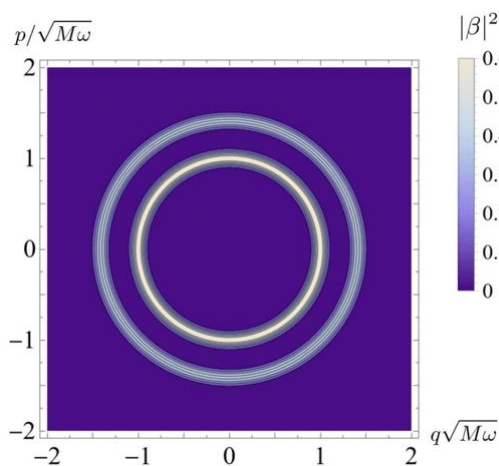
Conversely, [Einstein's theory of general relativity](#), which deals with larger objects like stars and galaxies, depicts time as intertwined with space, capable of warping and dilating under high speeds or strong gravitational fields. This discrepancy creates a significant conflict between our two best theories of reality, preventing the formulation of a coherent theory of everything.

"It seems there is a serious inconsistency in quantum theory," Coppo said. "This is what we call the problem of time."

To address this, the researchers revisited the Page and Wootters mechanism, a theory proposed in 1983. It suggests that time emerges through quantum entanglement between one object and another acting as a clock. In an unentangled system, [time does not exist](#), and the universe appears frozen and unchanging.

Applying this mechanism to two entangled but noninteracting theoretical quantum states—a vibrating harmonic oscillator and a set of tiny magnets acting as a clock—the researchers found their system aligned perfectly with the [Schrödinger equation](#), which predicts the behavior of quantum objects. Instead of traditional time, their version of the equation ran according to the states of the tiny magnets.

While this concept isn't entirely new, the team's next step was groundbreaking. They repeated their calculations, assuming first that the magnet clock and then the harmonic oscillator were macroscopic objects. The equations simplified into those used in classical physics, suggesting that [time's flow](#) is a consequence of entanglement even on large scales.

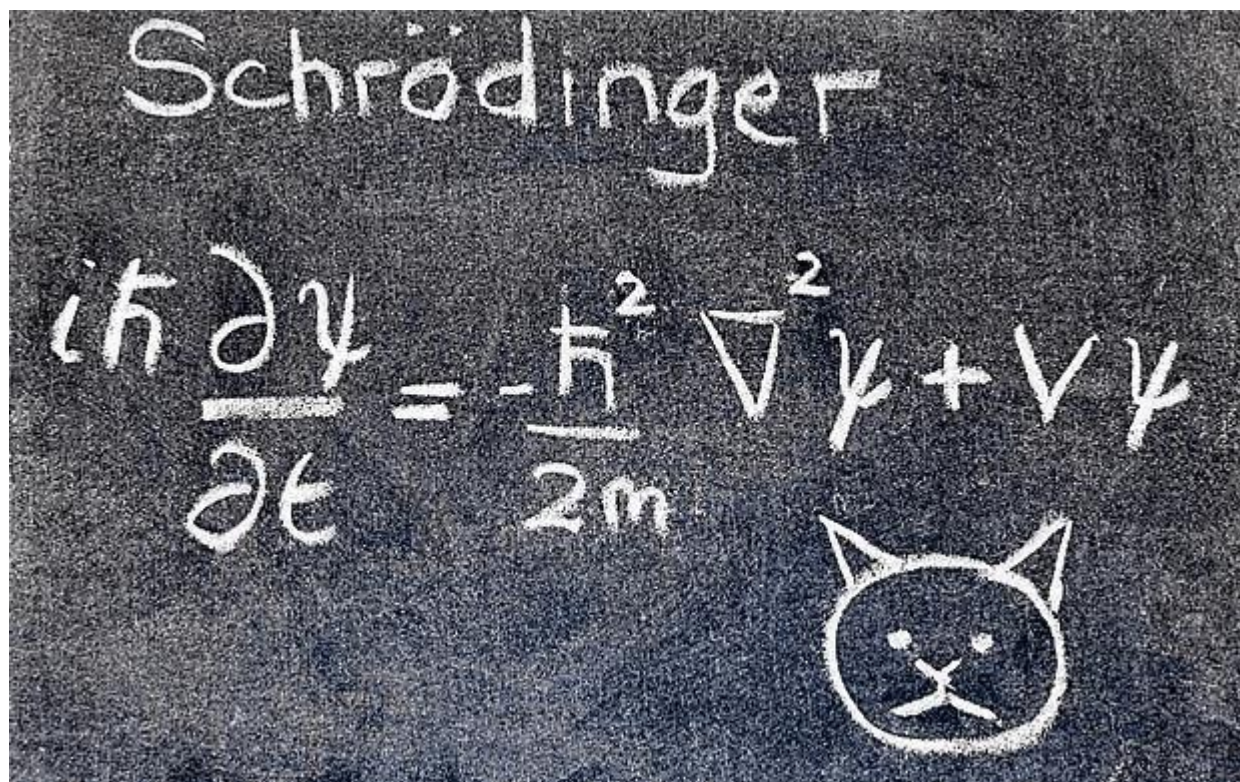


The contour plot of the marginal probability distribution related to $|\beta|2$ with respect to the evolving system phase-space coordinates. (CREDIT: Physical Review A)© The Brighter Side of News

"We strongly believe that the correct and logical direction is to start from quantum physics and understand how to reach classical physics, not the other way around," Coppo asserted.

Despite the intriguing possibilities, other physicists urge caution. They find the idea of the Page and Wootters mechanism fascinating but note that it has yet to produce testable results.

"Yes, it is mathematically consistent to think of the universal time as the entanglement between [quantum fields](#) and quantum states of 3D space," commented Vlatko Vedral, a professor of quantum information science at the [University of Oxford](#), who was not involved in the work. "However, no one knows if anything new or fruitful will come out of this picture—such as modifications to quantum physics and general relativity, and corresponding experimental tests."



Researchers found their system aligned perfectly with the Schrödinger equation, which predicts the behavior of quantum objects. (CREDIT: CC BY-SA 3.0)© The Brighter Side of News

Despite these doubts, building theories of time from quantum mechanics might still be a promising approach, provided they can be validated through experiments.

"Maybe there is something about entanglement where it plays a role," suggested Adam Frank, a theoretical physicist at the [University of Rochester](#) in New York, who was not involved in the study. "Maybe the only way to understand time is not from some God's-eye perspective, but from the inside, from a perspective of asking what is it about life that manifests such an appearance of the world."

In summary, this new perspective on time as an emergent property from quantum entanglement could open up new avenues for [understanding the universe](#).

However, it remains crucial to develop these theories in ways that can be experimentally tested to bridge the gap between quantum mechanics and general relativity.

The size of the human brain ebbs and flows over the course of millennia, but a new study has shown an uptick in size between the brains of people born from the 1930s and those born in the 1970s.

- This increased brain size—noticeable in volume, surface areas, and structures such as the hippocampus—could be attributed to better health outcomes and educational opportunities.
- Increased brain size could also help explain why the incidence of dementia is decreasing, as bigger brains offer a buffer against “late-life effects” of brain diseases, such as Alzheimer’s.

The human brain is one of the most impressive [organs](#) in the animal kingdom. By far the most advanced cerebrum nature has ever produced (at least, as far as we know), the brain consistently confounds scientists who are trying to understand its many mysteries—and those mysteries can even extend to its very size.

Over the course of human biology—measured in *millions* of years—some scientists have put forward the idea that the [human brain is actually shrinking](#), fueled in part by the knowledge that human bodies have shrunk in size. Some

research even posits that [a warming world](#) could be an engine behind brain change.

However, new research from University of California Davis suggests that on smaller timescales—that is, biological changes between [generations](#)—the brain's volume has actually *increased* by 6.6 percent. While that may not seem like a lot (the brain is essentially the size of two clenched fists, after all), it could be a useful biological bulwark against dementia. The results of this study were published this week [in the journal JAMA Neurology](#).

"The decade someone is born appears to impact brain size and potentially long-term brain health," UC Davis's Charles DeCarli, first author of the study, [said in a press statement](#). "Genetics plays a major role in determining [brain](#) size, but our findings indicate external influences—such as health, social, cultural and educational factors—may also play a role."

This research pulls data from a community-based study first [launched back in 1948](#) and continuing to this day. Though the [MRIs](#) themselves were conducted between 1999 and 2019, this long-term dataset includes second and even third-generation participants. This allowed DeCarli's team to analyze changes in brain structures over time, particularly for those born in the 1930s until the 1970s.

However, the study is limited. For example, though it analyzes people between the ages of 30 and 62, the average age at the time of MRI was 57. The dataset also features a dearth of non-white participants, so it's not an excellent indicator of the U.S. [population](#) as a whole. But it does show something—drastic changes happening in the human brain.

As mentioned, the average volume of the brain was found to have increased 6.6 percent, but the cortical surface area showed an overall 15 percent increase in volume when comparing participants from the 1970s to those in the 1930s. In addition, structures of the brain—such as white matter, gray matter, and the hippocampus—also increased in size over the decades. The researchers attribute this *growing* trend to improved "early life [environmental](#) influences," including improved health, social-cultural changes, and education factors.

And while 7 million Americans live with brain diseases like [Alzheimer's](#), the incidences of those [diseases overall have decreased by 20 percent](#) since the

1970s. DeCarli's research could provide evidence that an increased brain size might be part of the reason why.

"Larger brain structures like those observed in our study may reflect improved brain development and improved brain [health](#)," DeCarli said in a press statement. "A larger brain structure represents a larger brain reserve and may buffer the late-life effects of age-related brain diseases like Alzheimer's and related dementias."

Once again, the brain shows the (increased) capacity to [surprise](#).

20 Fascinating Facts About the Human Brain

Prepare to be amazed as we delve into the extraordinary world of the human brain! This incredible organ not only orchestrates our thoughts, emotions, and behaviors but also holds secrets that are as fascinating as they are vital to understanding ourselves. From its astonishing capacity to generate electricity to its ability to adapt and heal, join us as we explore some of the most interesting and surprising facts about the human brain that will surely captivate your curiosity.

The Brain's Water Content

The human brain is approximately 75% water. This high water content is crucial as it helps maintain chemical processes, delivers nutrients to brain cells, and removes waste. Dehydration, even in small amounts, can affect cognitive function and the ability to think clearly.

Neuron Count

There are roughly 86 billion neurons in the human brain. Each neuron is capable of forming thousands of connections with other neurons, leading to an almost infinite number of potential neural pathways. This vast network is what allows for the complexity of human thought, memory, and emotion.

Electrical Power

The brain operates on the same amount of power as a 10-watt light bulb, even when you're sleeping. The electrical activity generated by the brain is enough to power a small light bulb, highlighting the organ's efficiency and energy management.

Blood Vessels Length

If stretched out, the blood vessels in the brain would be about 100,000 miles long. This extensive network ensures that brain cells receive a constant supply of oxygen and nutrients essential for optimal function.

New Neurons

The adult human brain can grow new neurons, a process known as neurogenesis. Primarily occurring in the hippocampus, this phenomenon is vital for learning and memory. It challenges the old belief that adults cannot grow new brain cells.

Brain Weight

The average adult human brain weighs about 3 pounds, which is about 2% of total body weight. Despite its weight, it uses about 20% of the body's energy and oxygen intake, emphasizing its importance and metabolic demand.

Synapses

For each neuron, there can be between 1,000 to 10,000 synapses, amounting to over 100 trillion in total. This immense network of connections is what allows for complex thought, learning, and the formation of memories.

Speed of Information

Information in the brain travels at different speeds but can be as fast as 270 miles per hour. This fast processing speed enables quick reflex responses and seamless coordination of physical actions.

Oxygen Usage

The brain consumes about 20% of the oxygen we breathe in. Its high oxygen use reflects its intense metabolic activity, required for maintaining normal cognitive and neurological functions.

The Visual Brain

Around 30% of the brain's cortex is devoted to visual processing, more than any other sense. This extensive area highlights the importance of vision in human evolution and function.

Memory Capacity

The storage capacity of the human brain is considered to rival about 2.5 petabytes of binary data, which is equivalent to about three million hours of TV shows. This vast capacity allows humans to store a tremendous amount of information over a lifetime.

Protective Blood-Brain Barrier

The brain is protected by a selective barrier called the blood-brain barrier, which prevents most substances in the blood from entering the brain. This feature is essential for protecting the brain from pathogens and toxins.

The Brain's Clock

The suprachiasmatic nucleus in the brain acts as the master clock, coordinating all the biological clocks in a human body, regulating circadian rhythms, and ensuring timely hormone release for sleep and other body functions.

Processing Power

The human brain can process images the eye sees for as little as 13 milliseconds — much faster than a blink, which takes about 100 to 400 milliseconds. This rapid processing ability is critical for quick reactions and seamless visual understanding.

Language and the Brain

The brain's left hemisphere is predominantly responsible for language abilities in right-handed individuals. This lateralization shows how certain high-level functions are compartmentalized within the brain.

Brain Growth

The human brain continues to grow until about the age of 25. This extended period of development is crucial for the maturation of advanced cognitive functions and emotional regulation.

Neural Plasticity

The brain has the remarkable ability to reorganize itself by forming new neural connections throughout life. This plasticity allows for learning new skills, adapting to new environments, and recovering from injuries.

Gamma Waves

The brain can produce gamma waves, which have a frequency of about 25 to 100 Hz and are associated with higher mental activity, including perception, problem-solving, and consciousness.

This article originally appeared on [UnifyCosmos](#).

The three-pound human brain is one of the most intricate organs, surpassing the most advanced supercomputer. It controls everything you do, from reading this sentence to dreaming up wild inventions. Despite being a small organ, the brain is packed with complexities scientists are still trying to understand.

Stores Massive Data

Our brains can reserve 2.5 petabytes of data, equivalent to roughly 3 million hours of TV shows. This immense capacity allows us to retain a lifetime of memories and experiences. Thanks to the intricate 100 trillion neural networks, we quickly and accurately remember information.

Consumes 20% of Total Body Energy

Are you aware that your brain uses about 20% of your body's energy despite accounting for only about 2% of your body weight? The high energy demand is necessary to support continuous electrical activity, which coordinates every thought, movement, and sensation.

A Fast Information Processor

Neurons in the brain can transmit information at high speeds of up to 268 miles per hour. The brain's rapid transmission facilitates quick reflexes, instant decision-making, and seamless body movement coordination.

A Lifetime Learning Machine

Human brains have the superpower to change and adapt throughout life. Neuroplasticity allows the brain to rearrange itself by creating fresh neural links whenever you learn or experience new things. A new lesson means a new connection.

Naps Fire Up Its Creative Potential

During naptime, the brain sometimes generates vivid, often surreal experiences that can inspire creativity and problem-solving. Nier Bohr, the physicist behind the atom's structure, credited this revelation with a dream. Scholars, linguists, and artists — across disciplines — report similar breakthroughs.

Powerful Emotional Processor

You're mistaken if you think your heart determines your emotions because that's the brain's job! The limbic system within the brain processes emotions using the amygdala, hippocampus, and hypothalamus to regulate all your emotional responses, including sexual stimulation, memory, and motivation.

It Has Two Areas Focused on Fluency

Our speech capability to understand and communicate is also part of the brain's functioning. The Wernicke's area controls word comprehension, and the Broca's area, working with the motor cortex, helps with speech production.

Directly Links to Your Gut

Have you ever felt happy or motivated after consuming certain foods? Coffee, chocolate, or berries? Well, that is because of the gut-brain axis. Specific foods interact with some neurotransmitters to influence mood, digestion, and overall well-being. The gut's network of neurons influences these changes.

Acts as a Memory Converter

The hippocampus, a small structure within the brain, forms and stores memories. After a while, the hippocampus converts short-term memories into long-term ones, helping the limbic system learn and recall better. Your brain makes remembering grade 2 math a piece of cake.

Powers Consciousness

Scholars — scientists, philosophers, and researchers — term consciousness as a state of awareness. When conscious, you can make decisions and solve problems faster because the brain's flexible response mechanism takes in information and reacts accordingly.

It Needs Sleep to Heal

As you sleep, your brain also takes a break and starts healing. It clears out toxins, consolidates memories, and supports learning and cognitive performance. This nightly restoration is crucial for maintaining mental health and overall well-being. Just make sure you sleep for 7-9 hours!

Stress Stresses the Brain

Chronic stress shrinks the hippocampus, affecting memory and learning. Stress also aggravates inflammation, spreading the damage to your heart. You can protect your brain from its demise by having a routine, getting enough sleep, exercising, and eating right.

Each Brain Hemisphere Has Specialized Jobs

The brain has two hemispheres: the left hemisphere handles all the logical reasoning and language tasks, and the right, creativity, non-verbal memory, and spatial awareness. The right side also controls muscles on the left side of your body and vice versa.

The Brain Dances to Music

When listening to your favorite jam, certain brain sections light up, evoking emotion, memory, and motor control. This incredible response shows how deeply music is wired into our neural circuitry. Music can also create new neural connections, keeping our brains healthy and young.

It Stores Scented Memories

Ever found a familiar scent instantly transporting you to a specific moment? That is because the brain stores all the memories and emotions associated with smells. The olfactory bulb links to the hippocampus and amygdala, making scents powerful triggers for emotional memories.

How the Brain Maps Out Space

By YASEMIN SAPLAKOGLU

When most of us walk into a grocery store, we can find our way around what is, in fact, a fairly complex maze. We navigate the aisles swiftly, swerving a cart around other shoppers, tight corners and piles of fruit. We can collect many items, check out and proceed to the exit without much thought.

We can do this because humans have an intrinsic navigation system that helps us move around without bumping into things, remember places we've been before, and locate ourselves and others in space. Only in the last few decades have scientists started to understand how this brain GPS works, propelled by two fundamental findings about the cells that store these maps.

The first came in the 1970s, when John O'Keefe, a neuroscientist at University College London, was recording the brain activity of rats freely moving about in a space. He observed that different subsets of neurons in the hippocampus, the part of the brain central to learning and memory, fired in response to the rats' specific locations. For example, if the rats were in the northeastern part of their space, one subset would fire; another subset was active when the rats were in the southwestern part. He concluded that the mammalian brain uses these so-called place cells to create a spatial map.

Then, in the early 2000s, May-Britt Moser and Edvard Moser, a then-married couple working together at the Norwegian University of Science and Technology, discovered "grid cells" in the entorhinal cortex, a region right next to the

hippocampus. These cells form an internal positioning system. Grid cells don't fire for one specific location, but rather encode a coordinate system represented as a hexagonal grid in the brain. If an animal navigates to one of the six vertices of its coded hexagon, that grid cell will fire.

Taken together, place cells and grid cells explain how the mammalian brain creates [a map of the world](#). In 2014, O'Keefe and the Mosers jointly won a Nobel Prize for their discoveries.

Of course, our internal navigation system isn't limited to grid and place cells. And new studies are finding that the same cells involved in mapping out space might also map out other kinds of information, such as time, abstract concepts and memories.

What's New and Noteworthy

When we navigate physical worlds, we're often navigating social ones, too. In a room there might be fixed objects, such as furniture, and ever-shifting social objects, as people walk in and out. By studying social fruit bats, Michael Yartsev, who studies the neural basis of behavior, and his team at the University of California, Berkeley found that [place cells encode](#) for both social and physical environments. The cells reacted not only to a bat's location, but also to the locations of other bats nearby, as *Quanta* reported in 2023. The cells also seemed to carry information about individual identities: The neurons fired differently if a bat flew near a friend than they did for an acquaintance.

As studies uncover more roles for place and grid cells, some scientists are

pondering whether the brain maps other knowledge the way it does space. For instance, cells might [structure conceptual spaces](#) like physical ones, according to research *Quanta* covered in 2019. In the study, participants watched on a screen as a bird silhouette was stretched and compressed. As the participants navigated this “bird space,” their cells fired in a hexagonal grid pattern just as if they were navigating a physical space. The findings suggested that the brain might represent many kinds of information in grids.

A few years ago, researchers discovered a limitation of these studies. Grid cells have usually been studied and mapped in two dimensions, as rodents scurry around a flat area. However, work *Quanta* [reported in 2021](#) shows that the brain encodes 2D space differently than 3D space. The hexagonal pattern that grid cells typically form in 2D disappears in 3D, a pair of studies showed. In three dimensions, grid cell activity becomes disorderly and complicated — a structural breakdown that suggests that grid cells may play a wider role in processes such as memory that aren’t strictly spatial.

“The brain has so many surprises for us,” Ila Fiete, a computational neurobiologist at the Massachusetts Institute of Technology, told *Quanta*. “Here’s this system that you kind of understand, and it’s orderly — and the brain just throws a curveball.”

Mind reading technology is hitting the market. It puts our thoughts at risk of being stolen, and renders privacy a relic of the past. There are many examples of neurotechnology devices hitting the market. For example, Elon Musk's neuralink is developing an implantable chip so individuals can move a computer

cursor with their mind. As well, Apple, Meta, and Open-AI are also hard at work on such devices.

The range of neurotechnology devices include devices that allow an individual to control computers with their mind. In many cases, people might not truly understand that their information is being shared and sold in the first place when they use these devices. And while medical research facilities must follow privacy laws, private companies have no such requirement. This despite the fact that they are among the most active collectors of brain data.

The Neurorights Foundation, a non-profit to protect people from the misuse or abuse of neurotechnology, found in a study that two-thirds of private companies already share or sell data to third parties. Yet they do not disclose data storage practices nor security protocols.

Mind reading AI systems can also be used to target passwords, including your Bitcoin password. Mind reading is the final frontier of privacy, and humanity appears woefully unprepared for it.

AI Mind-Reading Technology Exists Already

Mind reading technology has become so advanced that researchers have [successfully reconstructed](#) images from direct recordings of brain activity. Basically, the AI recreates images at which an individual is looking. AI reconstructed the original images with near-perfect accuracy.

One team conducted two different studies, placing volunteers inside a functional magnetic imaging (fMRI) machine, which measures blood flow changes in the brain.

Volunteers saw pictures of faces as the fMRI recorded the neural activity in the visual cortex, which was sent to the AI algorithm. The AI then reconstructed the images closely resembling the original pictures.

The second study entailed re-analyzing data from past experiments in which electrode arrays were implanted into macaque monkey's brain to record its activity while the primate looked at AI images.

The images created from the monkey's brain activity were almost identical to the original images, since the implanted devices provided precise data on the monkey's brain activity. The AI system learned which parts of the brain on which to focus when interpreting brain signals.

Present-day mind reading technology is so advanced that it can correlate brain activity with typed characters, defeating passphrase protection such as BIP39, the way in which crypto wallets create mnemonic phrases and convert them into binary seeds.

Mind Reading Technology Reads Minds Already

Change Will Come Quickly

The field of neuro technology evolves quickly. Soon AI technologies will be combined with large language models. Furthermore, researchers came up with a first ever non-invasive [mind-reading cap](#). While this technology is used for good—for instance, helping people unable to speak due to illness or injury—it at the very least poses novel privacy threats.

Abuse of mind technology would not be unprecedented. In the 1950s and 1960s, psychiatrists at America's top academic institutions supported CIA mind control misadventures like [ARTICHOKE](#) and [MK-ULTRA](#), which often entailed experimenting on vulnerable populations.

In an effort to protect consumer privacy, Colorado passed the first law in the nation to include biological and brain data in the State Privacy Act, which grants consumers new rights to their personal data and places obligations on data collectors.

The Colorado law went into effect last summer, and only applies to companies which identify the people whose information they are collecting, sharing, and selling.

Once mind-reading technologies advance beyond this state and into wireless technologies capable of long distances, the whole digital world is compromised. The dystopian world of 1984 would seem utopian by comparison.

In an age when companies access, analyze, and change brains, crypto technologists have a lot of work to preserve liberty through crypto for future generations. It might take a renewed human rights movement to make it happen

Smartphones Are So Over© Illustration by The Atlantic; Sources: Courtesy of Snap inc.

Today, Snap, the parent company of Snapchat, one of the most [popular](#) social-media apps for teenage users, is announcing a new computer that you wear directly on your face. The latest in its Spectacles line of smart glasses, which the company has been working on for about a decade, shows you interactive imagery through its lenses, placing plants or imaginary pets or even a golf-putting range into the real world around you.

So-called augmented reality (or AR) is nothing new, and neither is wearable tech. Meta makes [a pair of smart glasses in partnership with Ray-Ban](#), and claims they're so popular that the company [can't make them fast enough](#). Amazon sells an Alexa-infused version of the famous [Carrera frames](#), which make you look like a mob boss with access to an AI assistant (*Alexa, where's the best place to hide a body?*). Apple launched its [Vision Pro headset](#)—which includes an AR mode, along with a fully immersive virtual-reality one—last year. And who could forget [Google Glass](#)? Consumers have sometimes been cool on the face computers, if not [outright hostile](#) toward them, but tech companies just can't seem to quit the idea. From that perspective, it makes sense that Snap's new Spectacles are more a demonstration of intent than an actual product: They're targeted to developers who will apply and pay \$99 a month to use them.

But this is also, arguably, what makes them interesting. In an interview last week, Snap CEO Evan Spiegel told me that he sees smart glasses as an opportunity to

“reshape what a computer is, to make it something that actually keeps us grounded in the real world rather than behind a screen.” The company hasn’t accomplished this so far, of course, but the new Spectacles—and all those other smart glasses and AR headsets—are not being released into a void. They’re arriving at a moment when people are feeling pretty turned off by phones. People are angsty about how much time they spend looking down at small screens rather than engaging with the world around them. Parents are concerned that phones are driving [a teen mental-health crisis](#). Smartphone sales [have slowed](#), and even the latest iPhone [isn’t doing great](#). Companies are trying to get people excited about technology again, by pitching all sorts of new hardware ideas that break the bounds of that rectangular screen, such as lapel pins or [glorified walkie-talkies](#) that work with AI assistants. I had this moment in mind as I wore the new Spectacles earlier this month, batting colorful digital blobs away while Paramore’s “Misery Business” played in the background.

Among all the new glasses options, the Spectacles are distinct. They are oriented less toward utility—say, asking Alexa to set a timer—and more toward fun. In doing so, they offer a very specific formulation for the future of computing: that it should be amusing and connective. “If we look at the history of computers, they’ve actually always kept us indoors, taken us away from people that we love,” Spiegel told me. Growing up, he explained, he loved computers, but he had to go to the computer lab to use them, which meant forgoing the opportunity to hang out with friends during recess. He thinks smart glasses are an opportunity to reinvent screens by integrating computers more naturally into one’s life.

But Spectacles are still far from perfect. For starters, they are notably heavy. When I tried the glasses, they got warm to the touch after use, despite Snap’s assurances that it had invested in a state-of-the-art cooling system. They support up to 45 minutes of continuous usage, which isn’t very long. They reminded me of snorkeling goggles. You absolutely could not wear them in daily life without someone asking you what exactly you’ve got on your head. Their lenses can be dimmed to look like sunglasses, or made clear so people can still see your eyes. The glasses are controlled by your hands, held out in front of you. You pinch your index finger and your thumb together to “click.” (The onboarding process involves practicing by popping bubbles floating a few feet from your face.)

Mostly, they’re fun. Snapchat is famously popular with young people, and the glasses feel like a piece of hardware designed for this audience—closer to a

Nintendo Switch than a Google Glass. In one game developed in partnership with Lego, you can project virtual bricks onto your kitchen table and move them around to build different creations. Ask it for an additional small blue brick, and one appears before you. In collaboration with Niantic, the company behind *Pokémon Go*, Snap is also launching a game called *Peridot Beyond* that lets you care for virtual pets.

Perhaps most important, at least when it comes to Spiegel's bigger vision, the Spectacles can sync together, so that multiple people can see the same digital creations at once. In one experience, called *Imagine Together*, users can shout words to create cartoons that then appear in little bubbles on the screen. "Imagine a fox!" you might say, and then a small fox appears, floating in a bubble in midair between you and your friend.

Spiegel, who has four children, dreams that someday he'll see his kids playing together in augmented reality. I asked him what he might say to parents who would be nervous about their children adding an additional level of computing into their daily life. (Parents are already plenty concerned about screen time as is, without the screens being barely an inch from their teens' faces.) What would he say to the parents who just want their kids to go outside? Spiegel countered that he is a go-outside-and-play parent himself—but argued that the glasses could make playing together outside more fun.

At times, I found the Spectacles genuinely amusing, in a way the current Meta and Alexa glasses aren't. And yet, they still don't feel essential. Any device that's hoping to disrupt the smartphone will have to be extremely good. Whether smart glasses are indeed the future of computing will depend on whether someone can make a pair that's useful in day-to-day life. Spectacles aren't there yet; they're more novelty than utility. But the philosophical argument they make is a provocative one, even if it's just that right now—an argument. Like the imaginary pet I saw while wearing them, it technically exists, but just barely.

Snap's fifth generation of its Spectacles glasses is here, and they're big. Snap© Snap

- Snap unveiled its new Spectacles AR glasses at the Snap Partner Summit on Tuesday.

- CEO Evan Spiegel highlighted Spectacles' portability and lighter weight compared to competitors
- New Spectacles feature see-through lenses, an AI-powered 3D image generator, and a cordless design.

They may not hide your eyes, but Snap's new Spectacles won't pass as regular glasses.

At the end of Tuesday's [Snap Partner Summit keynote](#), CEO [Evan Spiegel](#) introduced a major upgrade to the company's augmented reality glasses.

He also didn't miss the opportunity to point out how much more portable and lighter the [Spectacles](#) are than the headsets offered by competitors.

"VR headsets, they feel like you've got a laptop taped to your face, and they're isolating," Spiegel said.

He added, "AR glasses have see-through lenses. They allow you to share experiences together with your friends in the real world, and they're lightweight and wearable."

That may be true, but Spotify's Spectacles still look like a tech gadget straight out of a 1980s futuristic science-fiction movie.

Spiegel said Snap worked to fit about 150 pounds worth of tech into a pair of AR glasses that weigh 226 grams — less than some [iPhone models](#).

For comparison, [Apple's Vision Pro headset](#) weighs between 600 and 650 grams, and Meta's Quest 3 is about 515 grams.

Shots of the Spectacles in action show how they fit on people's heads. Snap© Snap

Although Spiegel threw shade at headset rivals, Snap will have a lot to prove in the smart glasses space. Even a high-powered company like Meta is still finding its footing in the [AR market](#), as demonstrated by results at its Reality Labs unit.

"We have seen the losses on Reality Labs grow quarter by quarter, and investors have indulged this because Meta is making enough profit from its advertising business," Leo Gebbie, a principal analyst and director at CCS Insight, told [CNBC](#).

He added, "Snap is hugely more constrained. It's in a position where to meaningfully compete on hardware is going to be incredibly challenging."

The glasses Snap unveiled are cordless, unlike the Vision Pro headset. The [Quest 3](#) completely covers the eyes, but Spiegel said Spectacles have see-through lenses that become tinted in sunlight.

Still, the new Spectacles look bulky enough to prompt some double-takes in public at least, but that didn't stop Snap from taking one last jab at competitors with a skit.

In the video, people walked around wildly gesturing while wearing cartoonishly big headsets. The scene wasn't too far from the reality of the clickbait that came after the [Vision Pro launch](#) in February.

Spectacles users in the video wore sleeker black glasses that looked more like sunglasses than science fiction gadgets, but that doesn't mean they won't stand out in real life.

In the demonstrations, users could draw, play games, and use an AI-powered 3D image generator with the new glasses. They could even connect with other Spectacles owners to share their AR experiences.

The fifth-generation Spectacles are available to developers for \$99 a month with a 12-month guarantee, but it's unclear if the public will have access to this new version of the tech.

The first pair of Spectacles was launched in 2016. Although they looked more like sunglasses than their successors, the original pair came with a fraction of the tech capabilities.

Snap may have successfully made a pair of AR glasses that weigh less than an iPhone, but it still needs to convince investors that the public will line up for Spectacles 5.

1000 laptops on your pinkie — DNA storage and compute breakthrough could one day help store petabytes of data, but we're not there yet© Shutterstock / FlashMovie

Researchers from North Carolina State University and Johns Hopkins

University have developed a DNA-based technology capable of storing, retrieving, computing, erasing, and rewriting data.

This new advancement marks the first time all these tasks have been combined in a DNA storage system, with the potential to transform how data is stored in the future.

The project, led by Albert Keung, a professor at NC State, represents a leap forward for DNA computing. While DNA has long been seen as a potential solution for long-term data storage, it had not previously been capable of handling multiple operations like modern electronic systems. The team's new system, however, has changed that.

Real-time data manipulation

The breakthrough was made possible through the creation of dendricolloids, a polymer structure that allows DNA to be stored densely without sacrificing capacity. "You could store the data of a thousand laptops in a DNA structure the size of a pencil eraser," Keung noted. This storage solution could be vital as global data demands continue to rise, particularly in areas such as AI, cloud computing, and large-scale data management.

In addition to storing data, the system allows for real-time data manipulation, including copying, erasing, and rewriting DNA sequences. Kevin Lin, the paper's lead author, explained, "We can perform many of the same tasks as with electronic devices - like deleting and rewriting data on the same surface."

The system has also demonstrated computational abilities, solving simple problems such as Sudoku puzzles and chess problems. The research team believes that this development could pave the way for molecular computing, potentially storing petabytes of data in very small spaces.

Although the technology is still in its early stages, the researchers hope it will lead to practical applications in the future. The study was published in [Nature Nanotechnology](#) and supported by the National Science Foundation.

Credit: Pixabay.© ZME Science

For billions of years, DNA has quietly carried the [blueprints for all life](#) on Earth, encoding instructions for everything from the simplest bacteria to the most complex mammals. Relative to this timeline, the discovery of DNA's double helix in 1953 happened only an instant ago. But now, in a clever move, scientists are harnessing DNA not just to record life's instructions, but as a powerful biological computer.

Researchers at North Carolina State University and Johns Hopkins University have developed a technology that, for the first time, enables DNA to perform the full suite of computing functions — storing, retrieving, erasing, and rewriting data — just like a traditional computer. In early tests, this DNA computer even solved puzzles, like simplified versions of sudoku and chess.

DNA: The Future of Data Storage?

DNA is nature's ultimate [data storage](#) medium, capable of storing vast amounts of information in the tiniest volume. Each cell in the human body contains approximately 800 MB of data, according to scientists' estimates. But, despite its potential, synthetic systems have struggled to match the versatility of electronic devices when it comes to managing data.

Until now.

This new technology, described as a "primordial DNA store and compute engine," promises to change that. Researchers have demonstrated that DNA-based

systems can not only store data, but also perform complex tasks like computing, rewriting, and moving information.

The key to this breakthrough lies in a soft polymer scaffold known as a dendricolloid. These tiny, tree-like structures offer a stable environment for DNA, holding the delicate molecules securely while still allowing them to perform complex tasks. By using this material, the researchers were able to achieve what was once thought impossible: a DNA system that can manage data reliably, even after repeated use.

"We've demonstrated that these DNA-based technologies *are* viable, because we've made one," says Albert Keung, a molecular biologist and co-lead of the study.

Solving Sudoku with DNA

In experiments, the system was able to process basic calculations, including solving small puzzles such as 3×3 chess grids and sudoku. The researchers hope that their work will spark a new era of molecular computing, one that goes beyond simple storage and into the realm of full-fledged biological machines.

What makes this system remarkable compared to previous DNA-based computers is its flexibility. By using enzymes to copy and rewrite data without harming the original DNA, the researchers were able to simulate file deletion and retrieval — the DNA equivalent of erasing a hard drive and filling it with new files. This opens the door for DNA systems that can handle complex, evolving data sets.

"We wanted to develop something that would inspire the field of molecular computing," says Keung. "And we hope what we've done here is a step in that direction."

The advantages of DNA storage are staggering. With DNA's incredible data density, a sugar-cube-sized amount could store 10 million gigabytes (GB) of data. That's the equivalent of thousands of laptops crammed into an object smaller

than a pencil eraser. And the stability of the system is remarkable — researchers believe it could last for millennia under the right conditions.

This makes DNA an ideal candidate for long-term, archival storage. If you're imagining vast data centers shrinking to the size of a closet, you're not far off the mark. You could store this data for thousands or even millions of years in frozen DNA. Moreover, the team's material can withstand more than 170 cycles of dehydration and rehydration — compared to just 60 cycles with DNA stored in simpler solutions — making it incredibly robust for long-term use.

"The ability to distinguish DNA information from the nanofibers it's stored on allows us to perform many of the same functions you can do with electronic devices," the researchers wrote in their study. This includes copying data without damaging the original, and erasing and rewriting specific pieces of information.

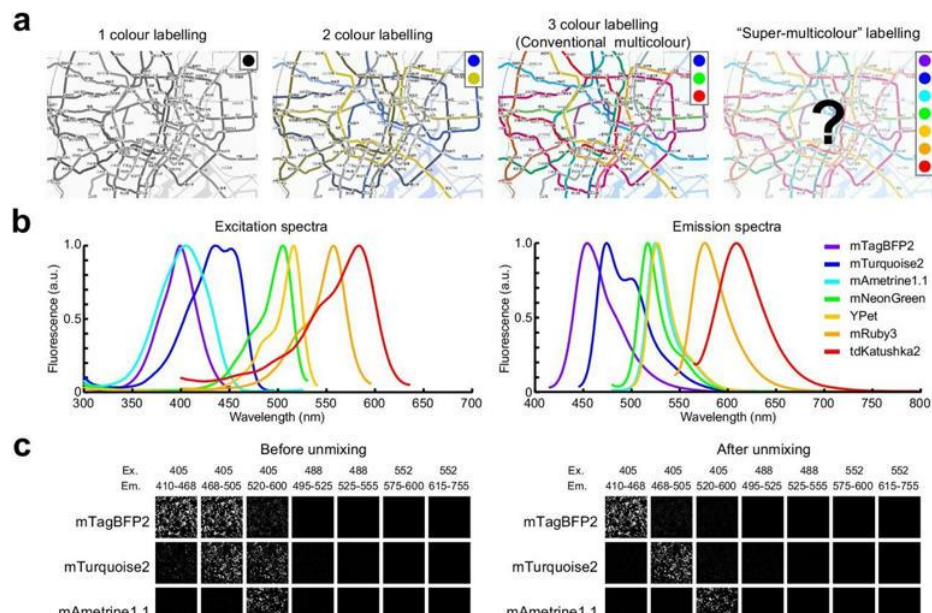
What Does This Mean for the Future?

Although the current system is far from rivaling supercomputers in speed or power, the long-term vision is compelling. A DNA-based archive that stores the sum of all human knowledge that could survive the rise and fall of civilizations. Researchers also see potential applications in fields like medicine, where biological data could be processed in real-time within living organisms.

For now, the research is still in its early stages. But by solving these foundational challenges, scientists like Keung hope to inspire a new wave of molecular computing. "We wanted to develop something that would inspire the field," he says. "And we hope what we've done here is a step in that direction."

While the road to a DNA-based future is still long, this latest breakthrough signals a fascinating new frontier in computing.

The findings appeared in the journal [Nature Nanotechnology](#).



7-color fluorescence imaging with linear unmixing. Credit: Nature Communications (2024). DOI: 10.1038/s41467-024-49455-y© Provided by Medical Xpress

The brain is the most complex organ ever created. Its functions are supported by a network of tens of billions of densely packed neurons, with trillions of connections exchanging information and performing calculations. Trying to understand the complexity of the brain can be dizzying. Nevertheless, if we hope to understand how the brain works, we need to be able to map neurons and study how they are wired.

Now, publishing in *Nature Communications*, researchers from Kyushu University have developed a new AI tool, which they call QDyeFinder, that can automatically identify and reconstruct individual neurons from images of the mouse brain. The process involves tagging neurons with a super-multicolor labeling protocol, and then letting the AI automatically identify the neuron's structure by matching similar color combinations.

"One of the biggest challenges in neuroscience is trying to map the brain and its connections. However, because neurons are so densely packed, it's very difficult and time-consuming to distinguish neurons with their axons and dendrites—the extensions that send and receive information from other neurons—from each

other," explains Professor Takeshi Imai of the Graduate School of Medical Sciences, who led the study.

"To put it into perspective axons and dendrites are only about a micrometer thick, that's 100 times thinner than a standard strand of human hair, and the space between them is smaller."

One strategy for identifying neurons is to tag the cell with a fluorescent protein of a specific color. Researchers could then trace that color and reconstruct the neuron and its axons. By expanding the range of colors, more neurons could be traced at once. In 2018, Imai and his team developed Tetbow, a system that could brightly color neurons with the three primary colors of light.

"An example I like to use is the map of the Tokyo subway lines. The system spans 13 lines, 286 stations, and across over 300 km. On the subway map each line is color-coded, so you can easily identify which stations are connected," explains Marcus N. Leiwe one of the first authors of the paper and Assistant Professor at the time. "Tetbow made tracing neurons and finding their connections much easier."

However, two major issues remained. Neurons still had to be meticulously traced by hand, and using only three colors was not enough to discern a larger population of neurons.

The team worked to scale up the number of colors from three to seven, but the bigger problem then was the limits of human color perception. Look closely at any TV screen and you will see that the pixels are made up of three colors: blue, green, and red. Any color we can perceive is a combination of those three colors, as we have blue, green, and red sensors in our eyes.

"Machines on the other hand don't have such limitations. Therefore, we worked on developing a tool that could automatically distinguish these vast color combinations," continues Leiwe. "We also made it so that this tool will automatically stitch together neurons and axons of the same color and reconstruct their structure. We called this system QDyeFinder."

QDyeFinder works by first automatically identifying fragments of axons and dendrites in a given sample. It then identifies the color information of each fragment. Then, utilizing a machine-learning-algorithm the team developed

called dCrawler, the color information was grouped together, wherein it would identify axons and dendrites of the same neuron.

"When we compared QDyeFinder's results to data from manually traced neurons they had about the same accuracy," Leiwe explains. "Even compared to existing tracing software that makes full use of machine learning, QDyeFinder was able to identify axons with a much higher accuracy."

The team hopes that their new tool can advance the ongoing quest to map the connections of the brain. They would also like to see if their new method can be applied to the labeling and tracking of other complicated cell types such as cancer cells and immune cells.

"There may come a day when we can read the connections in the brain and understand what they mean or represent for that person. I doubt it will happen in my lifetime, but our work represents a tangible step forward in understanding perhaps the most complicated and mysterious dimension of our existence," concludes Imai.

More information: Marcus N. Leiwe et al, Automated neuronal reconstruction with super-multicolour Tetbow labelling and threshold-based clustering of colour hues, *Nature Communications* (2024). DOI: [10.1038/s41467-024-49455-y](https://doi.org/10.1038/s41467-024-49455-y)

Our microplastics problem isn't going away. These tiny fragments of plastic pollution have previously shown up in [our lungs](#), in [ancient rocks](#), and in [bottled water](#). A new study reveals the extent to which they're infiltrating the brain, too. An international team of scientists looked at the [olfactory bulbs](#) – the masses of brain tissue that take in smell information from the nose – in 15 deceased humans, and found the presence of microplastics in 8 of them.

Researchers have previously found microplastics [in brain blood clots](#), but this is the first published study to detect the material in actual brain tissue. Another [similar piece of research](#) is now undergoing [peer review](#).

"While microplastics have been detected in various human tissues, their presence in the human brain has not been documented, raising important questions about potential neurotoxic effects and the mechanisms by which microplastics might reach brain tissues," [write](#) the researchers in their published paper.

The researchers note that particles and fibers were the most common shapes, and [polypropylene](#) the most common polymer: it's one of the most widely used plastics, found in everything from packaging to car parts and medical devices. The particle sizes ranged from 5.5 micrometers to 26.4 micrometers, no more a quarter the width of the average human hair.

[Previous research](#) found air pollution particles making their way up the olfactory pathway – this latest study suggests microplastics could be using the same route to the brain, through tiny holes in the [cribriform plate](#) (just below the olfactory bulb).

"The identification of microplastics in the nose and now in the olfactory bulb, along with the vulnerable anatomical pathways, reinforces the notion that the olfactory pathway is an important entry site for exogenous particles to the brain," [write](#) the researchers.

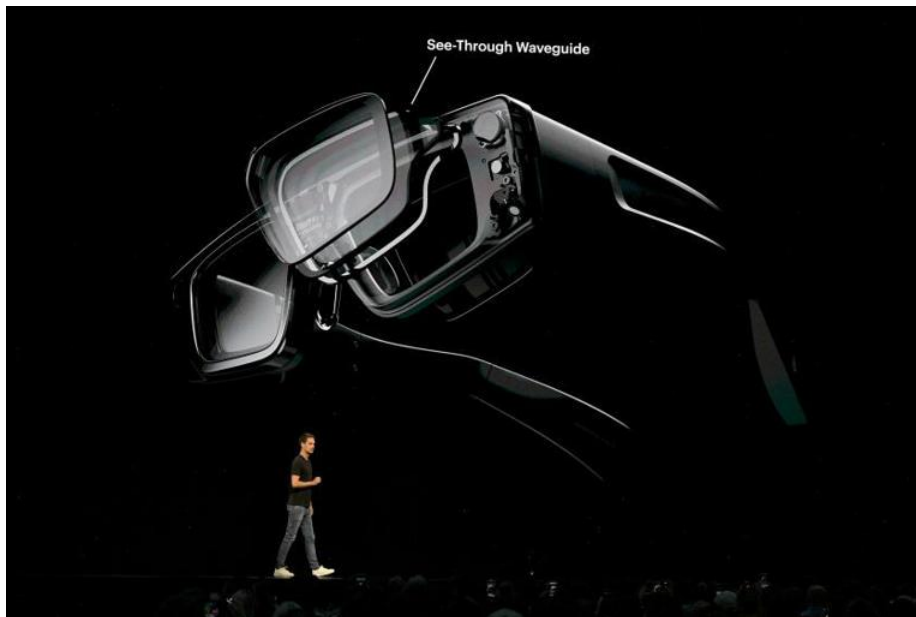
Despite all of these risks and health impacts, we don't seem to be able to cut down on our reliance on plastics. Despite ongoing efforts to produce plastic that's [more biodegradable](#), the fact is that plastic production has [doubled in the last 20 years](#).

What's not clear yet is what damage these microplastics might do to our own health, yet it's a safe bet that increasing concentrations of synthetic material inside the brain isn't good news. Neuron damage and increased risk of neuronal disorders are likely, based on [recent research](#).

There's also the nose connection to consider. A link between air pollution and cognitive problems has already [been well-established](#), and if microplastics are making their way into our nasal passages, that's likely to make matters worse.

"Some neurodegenerative diseases, such as [Parkinson's](#) disease, seem to have a connection with nasal abnormalities as initial symptoms," [write](#) the researchers.

The research has been published in [JAMA Network Open](#).



Evan Spiegel, chief executive of Snap Inc., speaks onstage during the Snap Partner Summit 2024 on Tuesday in Santa Monica. ((Charley Gallay / Getty Images for Snap Inc.))

In its relentless search for ways to weave digital products into people's lives, Big Tech has achieved some big wins. Smart phones are ubiquitous. Apple Watch users talk to their wrists. Artificial intelligence-powered assistants are everywhere. But convincing people to wear computers on their faces has been a dud. So far, at least.

Augmented reality glasses overlay digital images onto a person's view of the physical world. They're different from virtual reality headsets that fully immerse people into a computer-generated environment.

Tech giants have been focused in the last decade on developing eye glasses that project digital screens in front of a user's eyes. The fact that they have so far failed to convince people to wear smart glasses daily hasn't deterred Google and other companies from pouring money into the effort as they pursue a belief the hardware could one day reshape how people socialize, work and learn.

While dwarfed by the Silicon Valley behemoths to the north, Snap, the Los Angeles-based company behind the disappearing messaging app Snapchat is

competing in this smart glasses arms race. The company, which unveiled its fifth version of AR glasses at its annual conference Tuesday, hopes improving the device will drive mass consumer adoption.

"Making augmented reality glasses is really hard. And we know that the industry is littered with companies that have tried and we've been working for a really long time on these," Snap's Chief Executive Evan Spiegel said Tuesday from the stage at the conference as he unveiled the glasses.

Other industry giants including [Google and Samsung](#) are also working on smart glasses, and [Apple](#) is exploring the idea. The competition raises the stakes for the publicly traded Snap as it looks to new products to help reassert itself in the tech world as rivals such as Instagram and TikTok have surged past it to capture eyeballs and market dominance.

But a future in which augmented reality glasses are a part of our daily lives hasn't arrive yet and a long road still remains ahead, experts say. The future of smart glasses is still murky.

"This is a marathon. It's not a sprint," said Tuong Huy Nguyen, an analyst at Gartner who is part of a team that researches immersive technologies including AR. "We need an ecosystem of not just hardware and software but content to work together to create seamless experiences."

Snap first released [smart glasses](#) that could record video in 2016, selling them in vending machines in Los Angeles before making them available online. The company reported selling 150,000 pairs, but most people stopped [using them](#) after a month and underwhelming [demand for the gadget](#) resulted in hundreds of thousands of unsold pairs.

Named Spectacles, Snap's latest eyewear overlays computer-generated images onto a person's view of the physical world. The new device builds on the first AR glasses Snap released to software developers in 2021. Snap isn't selling to them to the public, but is making them available to software developers in hopes they'll design experiences for the platform.

What people can do with AR glasses remain limited. Snap's glasses can track a person's hands, allowing users to pick up and assemble virtual Legos, swing a phantom golf club, draw with friends and punch numbers in a digital calculator. It

also incorporates some artificial intelligence features that allows users to get answers to questions and conjure an image with a voice command.

In an attempt to drum up interest, Snap has been leaning into whimsical applications and gaming experiences that it knows users are used to, said Ben Bjarin, chief executive and principal analyst at Creative Strategies, a consulting firm that works with tech companies.

But Snap is still treading cautiously as it releases new AR glasses.

"What we can't predict is consumer adoption and so that's why we're taking this more thoughtful approach to how we're releasing this version," said Sophia Dominguez, Snap's director of AR Platform. "It could change at any time, and if it does change ... we're ready to go."

Dominguez said the company envisions AR glasses one day becoming the primary way people access the digital world. Instead of computer or phone screens, AR glasses, she said, will allow people to keep one foot in each world simultaneously, making it "easy for you to interact with technology in the same way that you interact with the real world."

Skepticism whether AR glasses will make this possible runs high.

Donning AR glasses could interfere with how people socialize in the physical world, making them feel less present, said Jeremy Bailenson, a Stanford University professor who founded the college's virtual human interaction lab.

"Wearing glasses that connect you to digital content, whether it's AR or VR should be done sparingly for special experiences," he said. "I am not an advocate of blocking your perceptual system, sight and sound for constant surveillance."

Bailenson and other [Stanford researchers](#) tested out the Meta Quest 3, a "mixed reality" headset that lets people blend physical and virtual worlds. While the headset is different from AR glasses, the gadget can display real-time video of a user's surroundings in the physical world.

Researchers, who were accompanied by a chaperone for safety reasons, wore Meta's headsets while chatting with people, walking around campus and cooking food. They reported that people in the physical world felt less real, as if they were watching television rather than interacting with someone face-to-face.

People wearing AR glasses will also see a different view of the world than people not wearing the devices and losing that “common ground” will likely impact the way people socialize, Bailenson said.

Previous attempts at integrating smart glasses into people's lives have not gone well. When Google released smart glasses in 2013 that could shoot photos, videos, they sparked privacy and safety concerns from consumers, lawmakers and business owners. People started calling [Google Glass owners](#) who used the smart glasses in ways that were socially unacceptable “glassholes.” Among the social no-nos: Surreptitiously recording others and reading on the device while seeming to ignore others.

And while AR glasses have the potential to be helpful in several arenas, including training, education, shopping and gaming, industry analysts said it will be difficult convincing consumers to embrace the devices.

"Our eyes are very precious real estate," said Bajarin, who tried out Snap's AR glasses ahead of their conference. "Consumers are going to guard that very, very heavily."

Keeping the price low enough to entice people to buy will also be a challenge. Meta, which partnered with Ray Ban on a pair of smart glasses that allows people to capture photos, listen to music and take video calls with the help of an AI assistant, sells its device for around \$300. Snap has not said what it will charge for its latest glasses should they become available to the public.

Snap's glasses remain a work in progress. They're heavier than regular glasses, heat up to an uncomfortable degree after extended use and the battery life is under an hour. They require foreign hand movements, such as reaching out to pinch digital objects in the air and tapping the front and back of one's hand to adjust the volume or launch a menu.

The device is powered by Snap's own operating system, giving the company more control over the experience. During a recent preview of the AR glasses held in a San Francisco home, a Times reporter used voice commands to create images that appeared almost instantly — a robot dog, Elsa from Frozen and the San Francisco skyline.

In another activity, a wide-eyed, yellow creature appeared before making its way outside to a real San Francisco patio with a stunning view of the city. Niantic, the maker of AR game Pokemon Go, created the experience "Peridot Beyond" for Snap's AR glasses.

Asim Ahmed, who leads global marketing at Niantic, said AR glasses gives the company the opportunity to experiment and design a "new kind of paradigm of gameplay." What works in a game played on a mobile phone might not work on AR glasses, which offer a wider field of view and don't rely so heavily on hands to play. Niantic also had to think about safety issues, including making sure the virtual pet doesn't get too close to their owner and blocks their view.

With an array of challenges, including figuring out how to jam processing power and other computing hardware into a device that is smaller than a smartphone, analysts predict it will take several years at least before smart glasses gain mainstream adoption, if they ever do.

In the first quarter of 2024, shipments of VR and AR headsets dropped 67.4% year-over-year but are expected to improve as consumers transition to new types of devices, according to market intelligence firm [IDC](#). Meta led the market, followed by ByteDance, Xreal and HTC.

With companies still testing out AR glasses or developing them, a clear front-runner hasn't emerged yet, analysts said.

Jacob Bourne, an analyst at eMarketer, said Snap's rivals, including Meta and Google, have more money to invest in research and development of AR glasses. Meta, which owns Facebook, Instagram and WhatsApp, has 3.27 billion people using one of their apps every day. Snapchat has 432 million daily active users.

"I would probably put my money more on Meta as having the key to the [research and development] capabilities to really get that to market," Bourne said. "But I wouldn't rule Snap out at all."

Snap's AR glasses are big and thick, but they can do mixed reality and hand tracking. They also have auto-dimming lenses. Scott Stein/CNET

At a hotel in New York, I stood on a terrace on a warm September day, leaning over and petting an adorable pet that wasn't there. The virtual Peridot buddy jumped around and followed me. It's much like other virtual pets I've tried on phones [and even headsets](#) such as the Meta Quest 3. This time, I saw it projected through see-through lenses that auto-dimmed like sunglasses to make sure the virtual experience was clearly seen in bright daylight. All I wore was this pair of chunky but standalone glasses: Snap's new AR Spectacles. Are these the future of something I might wear someday? If so, how long will it take until that happens?

I saw plenty of viral videos earlier this year of people wearing [Apple's Vision Pro](#) headset outside, for skiing, skating, in the park... wherever. The Vision Pro and Quest 3 headsets [aren't made for everyday outdoor use](#), but Snap's AR Spectacles are. Announced at the company's developer conference in Los Angeles, they're the latest iteration of Spectacles Snap's made for years. Snap first created standalone AR glasses back in 2021; [I tried those out](#) in my backyard during the pandemic. The new Spectacles are larger, but they're also more powerful. They have hand gestures like the Vision Pro and Quest 3, and also a whole Snap OS that can run a browser, launch different apps and connect with nearby phones.

These Snap glasses aren't even made for everyday people. They're developer hardware that's being offered on subscription, for \$99 a month as part of Snap's developer kit. That's a sign that Snap knows the world isn't ready for AR glasses yet, and neither is consumer technology. Snap is getting a foot in the door a little ahead of competitors.

Companies like Meta -- and likely Google and Apple -- are trying to get to smaller AR glasses that can overcome the chunkier limitations of mixed reality VR goggles. [I've seen attempts](#) to make glasses like these, but they usually have to tether to phones, computers or external processors of some sort to work and keep the glasses small.

Snap's AR Spectacles put all the processing and battery right on the glasses -- nothing else is needed. That means they could be worn easily without any extra cables, but the Spectacles in their current form are chunky and much odder than

any glasses I'd ever put on my face. The frames are thick, and the lenses still have rainbow-like patches in the middle where waveguides reflect virtual images projected from side-mounted LCOS miniprojectors.



The new Spectacles have thick arms that contain the processors, projectors and batteries. Scott Stein/CNET

The battery life is also extremely limited. At around 45 minutes, these are far from anything for all-day use. Although, like the 2021 version of Snap's AR glasses, these are still designed for developers. According to Snap's CTO and co-founder Bobby Murphy, these are exploratory devices to see how Snap's existing AR-enabled lenses on the Snapchat phone app can make a useful leap into glasses form.

This is the exact same approach Snap took back in 2021 but with a boost in processing power. Onboard are twin Qualcomm processors (I wasn't told which ones) that delivered some pretty crisp, if sometimes stuttery, graphics. The glasses only have a 46-degree viewing angle, which is OK for AR glasses but much less than VR headsets. It felt like I was watching mixed reality through a tall narrow window about the dimensions of a large phone screen.

One big difference between my 2021 demo and now is prescription lens inserts. I had to wear contacts last time, but snap-on lenses similar to what Meta and Apple already offer will work for these Spectacles. Unfortunately, Snap didn't have my prescription during the demo, so my AR morning was a bit fuzzy. It was good enough to see experiences.

An image from Snap of how group-shared experiences with hand tracking can work. In-glasses, the field of view is narrower than my own vision. Snap

Hand tracking, but no eye tracking

Snap's Spectacles use external cameras to track the world but add hand tracking like the Apple Vision Pro and Meta Quest headsets. I was able to tap virtual buttons, pet virtual creatures, paint in the air or pinch things at a distance. Snap OS has a dashboard of apps that floats in the air, plus virtual buttons that appear over my hand when I flip it over.

The Spectacles do not have eye tracking, so selecting objects takes a little more effort than Apple's glance-to-select Vision Pro. Phones can connect with the glasses too, offering another way to interact.

An extension for phones

One thing that's different about Snap's approach compared to Meta or even Apple right now is it's interconnected with phones. I tried several demos where I used a nearby phone to control AR experiences on the glasses. I used a phone like a remote to fly an AR helicopter around the room, using on-screen buttons for controls. I also held a phone like a golf club and swung to tee off in an AR golf course that looked like it was half-teleporting into the hotel room I was in.

Snap's Snapchat phone app will manage the glasses and also allow anyone else to connect and view the AR experiences I'm seeing on the glasses. According to Snap, the longer-term goal is to have phones using Snapchat interact with these glasses.

"We definitely think there's a lot of open space to continue to explore that connection between phones and Spectacles," Snap's Murphy says to me.



Snap's phone app works as an optional control dashboard for the glasses, and can become a controller too. Scott Stein/CNET

In the short term, the glasses are only made to work with other AR Spectacles wearers, and probably with good reason: Phone OSes don't play well with AR glasses yet. Both Apple and Google haven't made moves to make headsets and glasses feel truly integrated, and until they do, other companies are facing a compatibility bottleneck unless they use dedicated phone apps or, [like Xreal](#), build their own custom phone-like hardware. Even then, the connectivity isn't ideal.

Snap already [has a deep range of AR tools](#) on its Snapchat phone app, from world-scanning collaborative experiences to [location-specific AR](#). Snap's AR chops have improved since 2021, and these new glasses could take advantage of that.

Working with groups

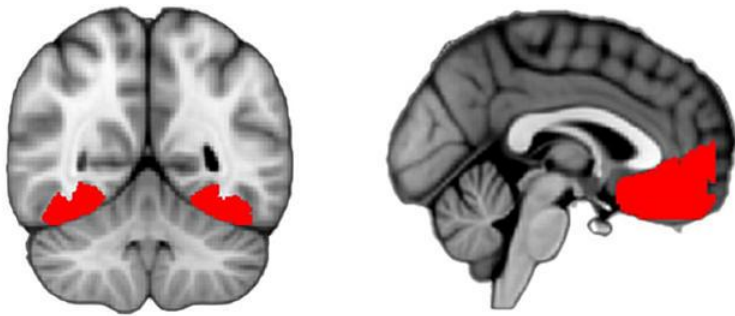
One thing I tried was collaborative painting. I used my fingers to draw in the air while one of Snap's team drew alongside me, wearing another pair of Spectacles. The glasses can recognize another nearby wearer and share an experience or even collaborate to scan a room with the four onboard cameras into a mesh for mixed reality.

Connecting in the hotel room wasn't always instant, but that glasses-to-glasses collaboration is a big part of the pitch here. Snap aims to have multiplayer

experiences with groups happen in outdoor areas, maybe even museums or art shows, to test out how well these can work for live immersive activations. A Lego brick-building experience was simple, but it showed possibilities if a bunch of people could make a site-specific sculpture together.

These glasses, made to be worn outdoors, have auto-dimming lenses similar to the tech on [Magic Leap 2](#). The Magic Leap 2 has a large external clip-on processor.

Some of the early partners Snap is working with include Niantic -- best known for [Pokémon Go](#) and a company that's also been exploring a future of [outdoor AR glasses](#) for years. Another partner, ILM Immersive, already made [Star Wars](#) and [Marvel experiences](#) on VR and mixed reality headsets.



Human brain-scan images show regions toward the back and front that are active for a person who is feeling curious.
Credit: Gottlieb Lab/Columbia's Zuckerman Institute© Provided by Medical Xpress

You look up into the clear blue sky and see something you can't quite identify. Is it a balloon? A plane? A UFO? You're curious, right? A research team based at Columbia's Zuckerman Institute has for the first time witnessed what is happening in the human brain when feelings of curiosity like this arise.

In a study published in the [*Journal of Neuroscience*](#), the scientists revealed brain areas that appear to assess the degree of uncertainty in visually ambiguous situations, giving rise to subjective feelings of curiosity.

"Curiosity has deep biological origins," said corresponding author Jacqueline Gottlieb, Ph.D., a principal investigator at the Zuckerman Institute. The primary evolutionary benefit of curiosity, she added, is to encourage living things to explore their world in ways that help them survive.

"What distinguishes human curiosity is that it drives us to explore much more broadly than other animals, and often just because we want to find things out, not because we are seeking a material reward or survival benefit," said Dr. Gottlieb, who is also a professor of neuroscience at Columbia's Vagelos College of Physicians and Surgeons. "This leads to a lot of our creativity."

Related video: This Is Where Scientists Are Looking for Signs of Alien Species (Dailymotion)

Joining Dr. Gottlieb on the research were Michael Cohanpour, Ph.D., a former graduate student at Columbia (now a data scientist with dsm-firmenich), and Mariam Aly, Ph.D., also previously at Columbia and now an acting associate professor of psychology at the University of California, Berkeley.

In the study, researchers employed a noninvasive, widely used technology to measure changes in the blood-oxygen levels in the brains of 32 volunteers. Called functional magnetic resonance imaging, or fMRI, the technology enabled the scientists to record how much oxygen different parts of the subjects' brains consumed as they viewed images. The more oxygen a brain region consumes, the more active it is.

To unveil those brain areas involved in curiosity, the research team presented participants with special images known as texforms. These are images of objects, such as a walrus, frog, tank or hat, that have been distorted to various degrees to make them more or less difficult to recognize.

The researchers asked participants to rate their confidence and curiosity about each texform, and found that the two ratings were inversely related. The more confident subjects were that they knew what the texform depicts, the less curious

they were about it. Conversely, the less confident subjects were that they could guess what the texform was, the more curious they were about it.

Using fMRI, the researchers then viewed what was happening in the brain as the subjects were presented with texforms. The brain-scan data showed high activity in the occipitotemporal cortex (OTC), a region located just above your ears, which has long been known to be involved in vision and in recognizing categories of objects.

Based on previous studies, the researchers expected that when they presented participants with clear images, this brain region would show distinct activity patterns for animate and inanimate objects. "You can think of each pattern as a 'barcode' identifying the texform category," Dr. Gottlieb said.

The researchers used these patterns to develop a measure, which they dubbed "OTC uncertainty," of how uncertain this cortical area was about the category of a distorted texform. They showed that, when subjects were less curious about a texform, their OTC activity corresponded to only one barcode, as if it clearly identified whether the image belonged to the animate or the inanimate category. In contrast, when subjects were more curious, their OTC had characteristics of both barcodes, as if it could not clearly identify the image category.

Also active during the texform presentations were two regions in the front of the brain. One is the anterior cingulate cortex, which previous studies implicated in information gathering. The other is the ventromedial prefrontal cortex (vmPFC), which is involved in monitoring a person's subjective perceptions of value and confidence about different situations. In the new study, both areas were more active when subjects reported being more confident in knowing a texform's identity (and thus, less curious to see the clarified image).

Three pairs of texforms showing unrecognizable and clear versions of objects. Credit: Gottlieb Lab/Columbia's Zuckerman Institute© Provided by Medical Xpress

Importantly, said Dr. Gottlieb, vmPFC activity seemed to provide a neurological bridge between the subjective feeling of curiosity and the OTC certainty measure. It's as though this region read out the uncertainty encoded by the distributed activity pattern in the OTC and helped a person decide if they needed to be curious about the texform.

"This is really the first time we can link the subjective feeling of curiosity about information to the way your brain represents that information," Dr. Gottlieb said.

The study has two important implications, Dr. Gottlieb said. First, although the study focused on perceptual curiosity elicited by visual stimuli, people experience other forms of curiosity, such as curiosity about trivia questions and factual matters (i.e. how tall is the Eiffel tower?) or social curiosity (which restaurant did my friends go to last night?).

One intriguing possibility of the study, she noted, is that the mechanism it has uncovered may generalize to other forms of curiosity. For example, an fMRI study investigating sounds of varying recognizability may show that auditory areas in the brain convey the uncertainty regarding the sound and the vmPFC reads out this uncertainty to determine curiosity.

A second possibility on Dr. Gottlieb's mind is that the findings could have diagnostic and even therapeutic implications for those with depression, apathy or anhedonia (the inability to feel pleasure), which are conditions often marked by a lack of curiosity.

"Curiosity entails a sort of enthusiasm, a willingness to expend energy and investigate your surroundings. And it's intrinsically motivated, meaning that nobody is paying you to be curious; you are curious merely based on the hope that something good will come when you learn," Dr. Gottlieb said. "Those are just some of the amazing things about curiosity."

More information: Michael Cohanpour et al, Neural Representations of Sensory Uncertainty and Confidence are Associated with Perceptual Curiosity, *The Journal of Neuroscience* (2024). DOI: [10.1523/JNEUROSCI.0974-23.2024](https://doi.org/10.1523/JNEUROSCI.0974-23.2024)



Spectacles with prescription lenses inside. I tried to match my own vision as best I could for the demo. Scott Stein/CNET

Are these a doorway for more AI wearables, and AI AR?

Snap's also partnering with OpenAI, a move that hardly seems surprising for 2024. This spring, a wave of camera-equipped AI wearables, including [Meta's Ray-Bans](#) and the [Humane AI Pin](#), tried to show promises of "multimodal" generative AI that could access cameras and audio inputs together for assistance or for generative AI creative apps. Mixed reality headsets like the Meta Quest 3 and Apple Vision Pro haven't tapped into camera-enabled AI yet because camera permissions have been more locked down for developers.

Snap's opening up its camera access more: OpenAI hook-ins can use the glasses' cameras and microphones for generative AI lens apps similar to what's available now on Snapchat's phone app. (Snap's also enabling camera access for AR apps, but online access is locked down for those apps, while camera access is open online for OpenAI connections.)

"Where people may want to use external services, we'll exercise more caution and control and work potentially with developers or third-party service providers to build those kinds of safeguards," Murphy says. On the Snapchat phone app, there

already are [generative AI tools](#) that use the camera. We may finally see some of these make the move to glasses now, too.

I tried generating some 3D emoji using Snap's generative AI, as well as navigating an educational solar system lens app that took my requests using my voice. I found responses during my demos were laggy, and the glasses didn't always understand what I was saying (although that was potentially the connection in the hotel room, or something else). Snap's opening up of camera access to AI-infused AR feels a step ahead of where Meta and Apple are currently. That could change soon, though: Meta is imminently expected to showcase new AI and AR updates, while Apple could introduce [Apple Intelligence features on Vision Pro](#) next year.



Scientists Create Microscopic Robots to Treat Brain Aneurysms Safely

Scientists have [developed](#) microscopic robots capable of treating brain aneurysms with unprecedented precision, offering a potential alternative to invasive brain surgeries.

An international team, including researchers from the University of Edinburgh, engineered these nanorobots to safely and accurately deliver life-saving medications to the brain. This advancement comes in the context of a global health challenge, as brain aneurysms claim approximately 500,000 lives annually.

The robots, measuring only 295 nanometers in diameter—about one-twentieth the size of a human red blood cell—are designed with magnetic cores and coated with thrombin, a clotting agent used to treat aneurysms. By comparison, a typical virus measures around 100 nanometers, and most bacteria are about 1,000 nanometers in size. The coating on these nanorobots is engineered to melt at specific temperatures, allowing doctors to release the medication in a controlled and targeted manner.

The scientists control the release of the medication by heating the robots using an alternating magnetic field, carefully regulated to prevent damage to the surrounding brain tissue. The process maintains a temperature below 122 degrees Fahrenheit (50 degrees Celsius), a critical threshold to ensure the delicate brain tissue is not harmed.

Nanorobots Tested on Rabbits Show Promising Results

During laboratory trials, the research team, which included clinicians from Shanghai Sixth People's Hospital, tested the nanorobots in both lab models and living subjects. In these experiments, doctors injected billions of nanorobots into an artery and used magnetic fields, combined with medical imaging technology, to guide them precisely to the site of the aneurysm. The trials were conducted on rabbits, where scientists artificially induced aneurysms in the carotid arteries, which are responsible for delivering blood to the brain and head.

The results were promising. Two weeks after the procedure, the researchers monitored the rabbits and found that the treated aneurysms exhibited stable clot formation. Crucially, these clots did not obstruct the overall blood flow to the brain, instead sealing off the weakened blood vessels at the aneurysm sites. This outcome demonstrates the precision and safety of the nanorobot approach, which offers a less invasive option compared to conventional brain surgery.

Reduced Risks Compared to Traditional Treatments

Current treatments for brain aneurysms typically involve threading a microcatheter through blood vessels to place metal coils or stents inside the aneurysm. This process can be both time-consuming and risky, with potential complications such as:

- **Rejection of materials:** The body may reject the metal coils or stents used in conventional treatments.
- **Adverse side effects:** Patients often need anti-blood-clotting medications, which can lead to significant side effects.
- **Lengthy, invasive surgeries:** Traditional methods require the brain to remain exposed for hours during surgery.

The nanorobot method, by contrast, does not require such extended invasive procedures, reducing the risks and complications associated with conventional brain surgeries.

Dr. Qi Zhou, from the University of Edinburgh's School of Engineering and one of the study's co-leads, stated that nanorobots have the potential to "open new frontiers in medicine," allowing for surgical procedures with fewer risks and greater precision. He highlighted that these robots could target drugs with pinpoint accuracy in areas of the body that are typically difficult to reach.

Further Testing Needed Before Human Trials Begin

While the results from these trials are encouraging, the research team has emphasized the need for further testing before the technology can be used in human patients. Specifically, they plan to conduct more extensive trials on animals and improve the control systems that guide the nanorobots, allowing them to navigate deeper within the brain. The rabbits in the current study had aneurysms located in shallow parts of the brain, enabling the researchers to demonstrate the technology's feasibility.

In addition to treating aneurysms, the study concluded that this nanorobot technology could be adapted for other medical applications. For example, the researchers have also designed nanorobots that could potentially remove blood clots, which may be useful in treating stroke victims in the future.

Qualcomm CEO Cristiano Amon revealed that the company is working with Samsung and Google to develop mixed-reality smart glasses connected to smartphones. This marks a distinct approach compared to Apple, which launched a bulkier mixed-reality headset, the Vision Pro. The collaboration is aimed at delivering more portable and convenient devices to the market.

Last year, the three companies [formed a partnership](#) to explore mixed-reality technology, which merges augmented and virtual reality by overlaying digital images on real-world environments. Amon's comments provide one of the first insights into this partnership. He expressed hopes that consumers with smartphones will also adopt companion smart glasses as part of the experience.

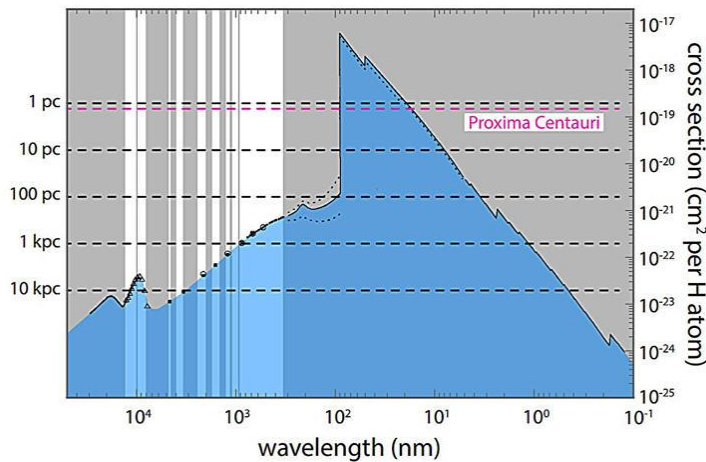
The mixed-reality glasses project remains in its early stages, with details still limited. Samsung and Google were unavailable for comment. However, Amon mentioned that this initiative is expected to introduce new products and experiences, with Qualcomm positioning itself at the forefront of this market through its Snapdragon AR1 Gen 1 chip, designed specifically for smart glasses. Qualcomm has been promoting the integration of AI in devices like smartphones and PCs, highlighting how AI can run on the device itself instead of relying on cloud processing.

The demand for AR and VR headsets, though growing, is still small compared to smartphones. According to the International Data Corporation, 9.7 million headsets are expected to ship this year, significantly lower than the forecast of 1.23 billion smartphones. A common complaint with current AR and VR devices is their large, uncomfortable design. Amon suggested that creating glasses resembling regular eyewear could address this issue and attract a wider audience.

Ray-Ban Meta smart glasses are powered by a Qualcomm chip. Qualcomm, Samsung and Google are working on smart glasses, according to Qualcomm CEO Cristiano Amon. Nurphoto | Nurphoto | Getty Images|Ray-Ban Meta smart glasses are powered by a Qualcomm chip. Qualcomm, Samsung and Google are working on smart glasses, according to Qualcomm CEO Cristiano Amon. Nurphoto | Nurphoto | Getty Images|Ray-Ban Meta smart glasses are powered by a Qualcomm chip. Qualcomm, Samsung and Google are working on smart glasses, according to Qualcomm CEO Cristiano Amon. Nurphoto | Nurphoto | Getty Images

Samsung, Google, and Qualcomm's smart glasses aim to deliver a different experience from [Apple's Vision Pro](#) headset, which is controlled through hand gestures and worn on the user's head. Although details about the product are still scarce, TM Roh, head of Samsung's mobile division, mentioned in an earlier

interview with CNBC that Samsung is working on a new “mixed-reality platform,” expected to be announced later this year. This platform will likely focus on software.



The allowable wavelengths for interstellar quantum communications. For a given distance away (left vertical axis), quantum communications are impossible where the horizontal distance line passes through the blue region of wavelength. Gray regions are off limits for ground-based telescopes. Credit: arXiv (2024). DOI: 10.48550/arxiv.2408.02445

Thus far, the search for extraterrestrial intelligence (SETI) has used strategies based on classical science—listening for radio waves, telescopes watching for optical signals, telescopes in orbit scouring light from the atmospheres of exoplanets, scanning for laser light that might come from aliens. Could a quantum mechanical approach do better?

Latham Boyle says maybe. "It's interesting that our galaxy (and the sea of cosmic background radiation in which it's embedded) 'does' permit interstellar quantum communication in certain frequency bands," he says.

A researcher at the Higgs Center for Theoretical Physics at the University of Edinburgh in Scotland, Boyle has investigated the possibility and says, "But whereas our current telescopes are big enough to allow interstellar 'classical' communication, interstellar 'quantum' communication requires huge telescopes—much bigger than anything we've built so far."

Further, his analysis leads to another potential solution to the Fermi paradox.

For interstellar communication, Boyle wrote "it is natural to ask whether it is also possible to send or receive interstellar quantum communications." His preprint was [released](#) on the *arXiv* preprint server and has been submitted to a peer-reviewed journal.

The idea is to use entangled qubit pairs, one kept by the sender and the other sent to Earth. A few years ago [it was discovered](#) that two quantum particles could retain a quantum coherence over interstellar and even galactic distances, even entangled with one another—somehow linked so that determining a property of one entangled qubit immediately determines that of the other.

This strange connection has already been [demonstrated](#) between photons over a thousand kilometers apart, with one on Earth's surface and the other in a spacecraft orbiting the planet.

A qubit is a unit of quantum information. Quantum mechanics allows, via quantum superposition, for a particle like a photon to be in two states at once, for example, spin up and spin down. Whereas in classical communication, a photon is in a single state, a bit, that is, either spin up or spin down, but not both at the same time. The qubit's difference makes them more powerful for many applications.

Boyle concentrated on the physical requirements and limitations of sending and detecting such a qubit signal, beginning with the "quantum capacity" of a transmission—the maximum rate at which a quantum communications channel can transmit quantum information.

Much is already known about quantum communications channels from studies and experiments of quantum teleportation, quantum cryptography, quantum entanglement and other quantum phenomena. Protocols based on quantum communication are exponentially faster than those based on classical communication—channels passing one bit at a time from transmitter to receiver—for some tasks.

Using known constraints on the quantum capacity for so-called [quantum erasure channels](#), and properties of the interstellar medium, Boyle was able to obtain two important results: a quantum capacity greater than zero requires the exchanged photons lie within certain allowed frequency bands, and that the effective diameter of both the sending and receiving telescopes must be greater than a

value which is proportional to the square root of the photon's wavelength multiplied by the distance between the telescopes.

According to Boyle's analysis, a quantum capacity that doesn't vanish requires the exchanged photons to have a wavelength less than 26.5 cm, mostly to avoid complications with the cosmic microwave background.

Moreover, while classical communications can happen if the receiver receives only a tiny percentage of the photons transmitted (as with radio signals), quantum communications requires that a majority of the photons sent be detected in the receiver's telescope.

For a ground-based telescope, that diameter would be enormous. The photon's wavelength must be at least 320 nm to get through Earth's atmosphere, and given that the distance to our nearest star, Proxima Centauri, is 4.25 light-years, Boyle finds a ground-based telescope would need to be at least 100 kilometers in diameter.

Needless to say, that's a vast difference from the largest ground-based telescope now under construction, the European [Extremely Large Telescope](#) under construction in Chile, which will have a diameter of 0.04 km (40 meters).

"In fact," Boyle said, "the required telescopes are so large that if the extraterrestrial sender has a big enough transmitting telescope, they can necessarily also see that we have not yet built a sufficiently large receiving telescope, so they would know that it doesn't yet make sense to communicate with us."

And that's maybe we haven't heard from them, he notes. "In other words, the assumption that extraterrestrials communicate quantum mechanically seems sufficient to explain the Fermi paradox."

Above the atmosphere, shorter wavelengths could be utilized that would require a smaller telescope, perhaps on the moon or at Earth's L2 Lagrange Point, but even gamma rays with wavelengths of order 0.001 nm would still require telescope diameters of about 200 meters.

The telescope need not be a single dish—it could be many small dishes packed close together (either on earth or in space), but they would have to close together, "like the cells in a honeycomb," Boyle said.

A series of relays or quantum repeaters could also be placed on the line between the sender and the target, but for diameters less than 100 meters the repeater telescopes would need to be placed every tenth of an astronomical unit, which includes inside our own solar system. Keeping them in alignment might be a problem (for them at first, not us).

A missing piece is how the receiver would know that an arriving signal is quantum mechanical instead of classical, "viz." part of an entangled pair, if aliens and humans start off with no prior communication. "I think that answer is at least one additional paper in its own right," Boyle said.

More information: Latham Boyle, On Interstellar Quantum Communication and the Fermi Paradox, *arXiv* (2024). DOI: [10.48550/arxiv.2408.02445](https://doi.org/10.48550/arxiv.2408.02445)

A layer 5 pyramidal neuron imaged in vivo with two-photon microscopy. The oblique dendritic domain (pink) contains stable synapses, and the basal dendritic domain (blue) contains plastic synapses. The cell body and part of the dendritic trunk are white. Credit: Courtney Yaeger and Mark Harnett

One of the brain's most celebrated qualities is its adaptability. Changes to neural circuits, whose connections are continually adjusted as we experience and interact with the world, are key to how we learn. But to keep knowledge and memories intact, some parts of the circuitry must be resistant to this constant change.

"Brains have figured out how to navigate this landscape of balancing between stability and flexibility, so that you can have new learning and you can have lifelong memory," says neuroscientist Mark Harnett, an investigator at MIT's McGovern Institute for Brain Research.

In research [published](#) in *Cell Reports*, Harnett and his team show how individual neurons can contribute to both parts of this vital duality. By studying the synapses through which pyramidal neurons in the brain's sensory cortex communicate, they have learned how the cells preserve their understanding of some of the world's most fundamental features, while also maintaining the flexibility they need to adapt to a changing world.

Visual connections

Pyramidal neurons receive input from other neurons via thousands of connection points. Early in life, these synapses are extremely malleable; their strength can shift as a young animal takes in visual information and learns to interpret it. Most remain adaptable into adulthood, but Harnett's team discovered that some of the cells' synapses lose their flexibility when the animals are less than a month old. Having both stable and flexible synapses means these neurons can combine input from different sources to use visual information in flexible ways.

Related video: 'People think it's like the Matrix': Neuralink's first patient on having a brain chip (Dailymotion)

Postdoc Courtney Yaeger took a close look at these unusually stable synapses, which cluster together along a narrow region of the elaborately branched pyramidal cells. She was interested in the connections through which the cells receive primary visual information, so she traced their connections with neurons in a vision-processing center of the brain's thalamus called the dorsal lateral geniculate nucleus (dLGN).

The long extensions through which a neuron receives signals from other cells are called dendrites, and they branch off from the main body of the cell into a tree-like structure. Spiny protrusions along the dendrites form the synapses that connect pyramidal neurons to other cells. Yaeger's experiments showed that connections from the dLGN all led to a defined region of the pyramidal cells—a tight band within what she describes as the trunk of the dendritic tree.

Yaeger found several ways in which synapses in this region—formally known as the apical oblique dendrite domain—differ from other synapses on the same

cells. "They're not actually that far away from each other, but they have completely different properties," she says.

Stable synapses

In one set of experiments, Yaeger activated synapses on the pyramidal neurons and measured the effect on the cells' electrical potential. Changes to a neuron's electrical potential generate the impulses the cells use to communicate with one another. It is common for a synapse's electrical effects to amplify when synapses nearby are also activated. But when signals were delivered to the apical oblique dendrite domain, each one had the same effect, no matter how many synapses were stimulated.

Synapses there don't interact with one another at all, Harnett says. "They just do what they do. No matter what their neighbors are doing, they all just do kind of the same thing."

The team was also able to visualize the molecular contents of individual synapses. This revealed a surprising lack of a certain kind of neurotransmitter receptor, called NMDA receptors, in the apical oblique dendrites. That was notable because of NMDA receptors' role in mediating changes in the brain.

"Generally when we think about any kind of learning and memory and plasticity, it's NMDA receptors that do it," Harnett says. "That is the by far most common substrate of learning and memory in all brains."

When Yaeger stimulated the apical oblique synapses with electricity, generating patterns of activity that would strengthen most synapses, the team discovered a consequence of the limited presence of NMDA receptors. The synapses' strength did not change. "There's no activity-dependent plasticity going on there, as far as we have tested," Yaeger says.

That makes sense, the researchers say, because the cells' connections from the thalamus relay primary visual information detected by the eyes. It is through these connections that the brain learns to recognize basic visual features like shapes and lines.

"These synapses are basically a robust, high-fidelity readout of this visual information," Harnett explains. "That's what they're conveying, and it's not context-sensitive. So it doesn't matter how many other synapses are active, they just do exactly what they're going to do, and you can't modify them up and down based on activity. So they're very, very stable."

"You actually don't want those to be plastic," adds Yaeger. "Can you imagine going to sleep and then forgetting what a vertical line looks like? That would be disastrous."

By conducting the same experiments in mice of different ages, the researchers determined that the synapses that connect pyramidal neurons to the thalamus become stable a few weeks after young mice first open their eyes. By that point, Harnett says, they have learned everything they need to learn. On the other hand, if mice spend the first weeks of their lives in the dark, the synapses never stabilize—further evidence that the transition depends on visual experience.

The team's findings not only help explain how the brain balances flexibility and stability; they could help researchers teach artificial intelligence how to do the same thing. Harnett says artificial neural networks are notoriously bad at this: When an artificial neural network that does something well is trained to do something new, it almost always experiences "catastrophic forgetting" and can no longer perform its original task. Harnett's team is exploring how they can use what they've learned about real brains to overcome this problem in artificial networks.

More information: Courtney E. Yaeger et al, A dendritic mechanism for balancing synaptic flexibility and stability, *Cell Reports* (2024). DOI: [10.1016/j.celrep.2024.114638](https://doi.org/10.1016/j.celrep.2024.114638)

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Provided by Massachusetts Institute of Technology

In a recent study published in the [Journal of Neuroscience](#), researchers have made a groundbreaking discovery: the subjective feeling of curiosity is linked to specific brain activity, which varies according to uncertainty. Using brain imaging, the team pinpointed how certain regions of the brain respond to ambiguous visual stimuli, helping to explain why we sometimes feel curious when we encounter uncertainty. This research provides novel insights into the neural basis of curiosity and offers clues about how curiosity might arise in various contexts.

Curiosity is a fundamental human trait. It drives us to learn, explore, and seek out new information, even when there are no direct rewards involved. While previous research has shown that curiosity engages brain areas linked to motivation and memory, there is still much to understand about how feelings of curiosity are generated. Specifically, scientists have wondered how our brain represents uncertainty and how this uncertainty might trigger curiosity.

Previous studies on curiosity often focused on questions or trivia and how people's confidence in knowing the answer influenced their curiosity. This research consistently showed that people tend to be more curious when they are less confident about the answer, suggesting a link between uncertainty and curiosity. However, the neural mechanisms behind this link remained largely unexplored. This new study set out to clarify these mechanisms by focusing on perceptual curiosity—curiosity triggered by ambiguous or distorted images rather than factual questions.

"The neural mechanisms that generate curiosity are very poorly understood. Perceptual curiosity — curiosity about ambiguous images — is particularly interesting, because it offers the possibility to understand how curiosity about an item (e.g., an image) arises from the way that the brain represents that item and specifically, about the uncertainty of that neural representation," said corresponding author [Jacqueline Gottlieb](#), a professor of neuroscience and principal investigator at Columbia University's Zuckerman Institute.

To investigate how uncertainty relates to curiosity, researchers recruited 32 participants who underwent brain scans using functional magnetic resonance imaging (fMRI), a noninvasive technology that tracks brain activity by measuring

changes in blood oxygen levels. As participants viewed images, the researchers could observe how various brain regions responded.

The visual stimuli used in the study were special images called "texforms." These texforms were images of animals or man-made objects, such as a walrus or a hat, that had been distorted to varying degrees. The distortion was designed to make the images more or less recognizable, thus creating different levels of uncertainty for the participants.

In each trial, participants viewed a texform and were asked to guess what the original image might be. They then rated both their confidence in their guess and their curiosity about seeing the undistorted image. Finally, the participants were shown the original image, giving them the "answer" to their guess.

Throughout the process, the researchers measured brain activity, focusing on specific regions like the occipitotemporal cortex (OTC), the ventromedial prefrontal cortex (vmPFC), and the anterior cingulate cortex (ACC). The OTC, located just above the ears, is a brain region involved in visual processing and object recognition, while the vmPFC and ACC are areas associated with subjective confidence, decision-making, and information-seeking behaviors.

The researchers found that participants' curiosity was inversely related to their confidence: the less confident they were about what the distorted image depicted, the more curious they were to see the original image. This relationship was expected based on previous studies involving trivia questions, but the researchers demonstrated it with visual stimuli, expanding the understanding of curiosity to perceptual domains.

One of the most significant findings was how curiosity corresponded to activity in the OTC. When participants were less curious, the OTC showed brain activity patterns that distinctly identified the texform's category, whether it was an animal or a man-made object. In other words, when participants were more curious, the OTC displayed more ambiguous activity patterns, suggesting that the brain couldn't clearly categorize the image, which heightened curiosity.

"I was pleasantly surprised to find a significant correlation between visual activity and curiosity," Gottlieb told PsyPost. "Of course, our study was conducted in the hope that we would find such a correlation. However, there were many reasons why we may have failed to find it — for instance, the fact that many processing

stages intervene between the visual activity and the subjective feeling that activity generates. So I was very gratified — and a bit surprised — to get the result we were hoping for.”

Furthermore, brain scans revealed that two additional areas—the vmPFC and ACC—were active during the task. The vmPFC, which is involved in evaluating confidence and value, showed increased activity when participants felt more certain about the texform’s identity, and decreased activity when curiosity was higher. This region appeared to act as a kind of “bridge” between the uncertainty represented in the OTC and the participants’ feelings of curiosity. It seemed to “read” the uncertainty from the OTC and helped determine whether the person needed to be curious about the image.

Interestingly, while both the vmPFC and ACC responded to confidence, only the vmPFC appeared to mediate the relationship between curiosity and the uncertainty in the OTC. This suggests that different brain regions may play distinct roles in how we experience and act on curiosity.

The findings demonstrate “that the brain has sophisticated mechanisms, which involve interactions among several areas, of signaling when you are uncertain and should become curious (ask a question) about something,” Gottlieb explained.

The study sheds new light on the neural mechanisms of curiosity. But there are limitations to consider. The study focused exclusively on visual curiosity, specifically curiosity about ambiguous images. It remains to be seen whether these findings can be generalized to other forms of curiosity, such as curiosity about trivia questions or social information. Future research will need to explore whether the same brain mechanisms are involved when people are curious about different types of stimuli.

“The results are so far specific to the images we used,” Gottlieb noted. “It is my hope that they will generalize to other types of curiosity (for example, curiosity about other images, or about trivia questions) but this remains to be determined in future research.”

The study also raises important questions about individual differences in curiosity. For example, are some people more prone to curiosity because of differences in how their brains process uncertainty? Could curiosity be linked to

personality traits or interests? These are open questions that future research could explore. Understanding how curiosity varies between individuals could have implications for education, where fostering curiosity is often a goal, and for mental health, where curiosity is sometimes diminished in conditions like depression.

"I would like to continue to understand the neural mechanisms that generate other forms of curiosity, and how they relate to individual interests and personality types," Gottlieb said.

The study, "[Neural Representations of Sensory Uncertainty and Confidence are Associated with Perceptual Curiosity](#)," was authored by Michael Cohanpour, Mariam Aly, and Jacqueline Gottlieb.

Visitors are often surprised and amused by the results of the Cybernetic Humanity Studio's facial morphing technology. Credit: Okinawa Institute of Science and Technology

Facial recognition is a critical part of self-image and social interactions. In an era of advanced digital technology, we face intriguing questions about communication and identity. How does altering our facial identity affect our sense of "self" and our interactions with others?

These are questions Dr. Shunichi Kasahara, a researcher in the Cybernetic Humanity Studio at the Okinawa Institute of Science and Technology (OIST) is investigating, using real-time morphing of facial images (turning our faces into someone else's and vice versa). The studio was established in 2023 as a platform for joint research between OIST and Sony Computer Science Laboratories, Inc.

Dr. Kasahara and his collaborators have investigated the dynamics of face recognition using motor-visual synchrony—the coordination between a person's physical movements and the visual feedback they receive from those movements.

They found that whether we influence the movement of our self-image or not, levels of identification with our face remain consistent. Therefore, our sense of agency, or subjective feelings of control, do not impact our level of identification

The effect of agency on perceptions of identity

With psychological experiments using displays and cameras, the scientists investigated where the "self-identification boundary" is and what impacts this boundary. Participants were seated and asked to look at screens showing their faces gradually changing.

At some point, the participants could notice a change in their facial identity and were asked to press a button when they felt that the image on the screen was no longer them. The experiment was done in both directions: the image changing from self to other and other to self.

"It's like watching your face in a mirror as you move it and you identify yourself, but your face slowly changes up to a point and you realize this is no longer you," Dr. Kasahara explained.

The researchers examined how three movement conditions affect the facial boundary: synchronous, asynchronous, and static. They hypothesized that if the motions are synchronized, participants would identify with the images to a greater extent.

Surprisingly, they found that whether movements were synchronized or not, their facial identity boundaries were similar. Additionally, participants were more likely to identify with static images of themselves than images with their faces moving.

Interestingly, the direction of morphing—whether from self to other or other to self—influenced how participants perceived their own facial boundaries: participants were more likely to identify with their facial images when these images morphed from self to other rather than from other to self. Overall, the results suggest that a sense of agency of facial movements does not significantly impact our ability to judge our facial identity.

"Consider the example of deepfakes, which are essentially a form of asynchronous movement. When I remain still but the visual representation moves, it creates an asynchronous situation. Even in these deepfake scenarios, we can still experience a feeling of identity connection with ourselves," Dr. Kasahara explained.

"This suggests that even when we see a fake or manipulated version of our image, for example, someone else using our face, we might still identify with that face. Our findings raise important questions about our perception of self and identity in the digital age."

How does identity impact perceptions of control?

What about the other way around? How does our sense of identity impact our sense of agency? Dr. Kasahara [published a paper](#) in collaboration with Professor of Psychology at Rikkyo University, Dr. Wen Wen, who specializes in research on our sense of agency. They investigated how recognizing oneself through facial features might affect how people perceive control over their own movements.

During experiments, participants observed either their own face or another person's face on a screen and could interact and control the facial and head movements. They were asked to observe the screen for about 20 seconds while moving their faces and changing their facial expressions.

The motion of the face was controlled either only by their own facial and head motion or by an average of the participant's and the experimenter's motion (full control vs. partial control). Thereafter, they were asked "how much did you feel that this face looks like you?" and "how much control did you feel over this presented face?"

Again, the main findings were intriguing: participants reported a higher sense of agency over the "other face" rather than the "self-face." Additionally, controlling someone else's face resulted in more variety of facial movements than controlling one's own face.

"We gave the participants a different face, but they could control the facial movements of this face—similar to deepfake technology, where AI can transfer movement to other objects. This AI technology allows us to go beyond the conventional experience of simply looking into a mirror, enabling us to disentangle and investigate the relationship between facial movements and visual identity," Dr. Kasahara stated.

"Based on previous research, one might expect that if I see my own face, I will feel more control over it. Conversely, if it's not my face, I might expect to feel less control because it's someone else's face. That's the intuitive expectation. However, the results are the opposite—when people see their own face, they report a lower sense of agency.

"Conversely, when they see another person's face, they're more likely to feel a sense of agency." These surprising results challenge what we thought we knew about how we see ourselves in images.

Dr. Kasahara emphasized that the acceptance of technology in society plays a crucial role in technological advancements and human evolution.

"The relationship between technology and human evolution is cyclical; we evolve together. But concerns about certain computer technology may lead to restrictions. My goal is to help foster acceptance within society and update our understanding of 'the self' in relation to human-computer integration technology."

More information: Shunichi Kasahara et al, Investigating the impact of motion visual synchrony on self face recognition using real time morphing, *Scientific Reports* (2024). DOI: [10.1038/s41598-024-63233-2](https://doi.org/10.1038/s41598-024-63233-2)

Provided by Okinawa Institute of Science and Technology

Meta Quest VR/AR headsets are provably popular options for users seeking to embrace standalone and PCVR gaming without breaking the bank.

Affordability is one of the key reasons that the Meta Quest 3 fared so well against the ultra-specced (and ultra-priced) Apple Vision Pro, and such a level of accessibility could be a key reason that the company is said to have [ditched its plans for a high-end Meta Quest Pro follow-up](#).

However, the very same product roadmap review meeting that saw the cancellation of Meta's Quest Pro 2 headset reportedly saw the company

greenlight a new project codenamed 'Puffin,' and it sounds incredibly similar to the Vision Pro that Apple may have initially wanted to create and outright uncanny when compared to one of the leading AR smart glasses options on the market already.

It's [widely reported](#) that frames like this were Tim Cook and Jony Ive's original idea for the Vision Pro (and [a concept Apple appears to be returning to](#)), though it was a concept eventually abandoned due to the belief that available technology simply wasn't ready to bring the idea to life.

On the other hand, Meta believes it is. Or, at the very least, that it will be — with Project Puffin said to be targeting the same 2027 release as the now-canceled Quest Pro 2.

The best of both worlds?

Puffin will reportedly offer an opaque viewing experience through twin pancake lenses, with your only undeterred vision of the space around you coming from a set of passthrough cameras (potentially positioned similarly to the Ray-Ban Meta's camera and recording indicators).

This new Quest-like device is also said to tip the scales at just 110 grams, somewhere around the average weight of a deck of cards and roughly a fifth of the Meta Quest 3. It's also a little over twice the weight of the company's [Ray-Ban Meta Smart Glasses](#), which house open-ear speakers, a built-in camera, and battery.



((Image credit: Meta))

A wired workaround

One of the primary drawbacks of Meta's Ray-Ban Smart Glasses is battery life, with its paltry 154 mAh Lithium-ion battery not offering much in the way of longevity when it comes to continuous audio playback, media capture, or live streaming.

However, this new Quest-like wearable seeks to avoid battery issues like this by taking a page from Apple's Vision Pro playbook, relying on an external, pocketable, wired puck to house the battery and computing elements of the frames.

The external puck should be able to supply the frames with a far larger power bank and reduce any concerns about heat levels when engaging with AR or VR content.

Meta Connect 2024 recap: Mark Zuckerberg reveals 'Orion' smart glasses, new AI features, transparent Ray-Bans, and an affordable Quest 3S©Meta

- Mark Zuckerberg kicked off the Meta Connect 2024 developer conference on Wednesday with a keynote.
- The big news was his demo of Meta's first "true AR" prototype glasses, "[Orion](#)," which are still a work in progress.

- He also revealed new Meta AI features, limited-edition Ray-Ban smart glasses, and a \$299 Quest 3S.

[Mark Zuckerberg](#) knocked it out of the park during Meta's big day.

The [Meta](#) CEO took the stage on Wednesday to announce a slew of new AI and hardware products — including a teaser of the company's long-awaited fully holographic glasses, Orion.

The Orion glasses were the news of the day, and in a surprising turn for AR glasses, they looked ... pretty slick!

The smart glasses integrate visuals into the glasses lenses, the company's first "true AR" glasses. Notably, they appeared sleeker than the new [Snap Spectacles](#) that Snap CEO Evan Spiegel showed off last week. Zuckerberg ran a sizzle reel of famous names in tech reacting positively to the glasses, from Nvidia CEO Jensen Huang to Reddit CEO Steve Huffman.

But you'll have to wait a while to get your hands on them. The current prototype isn't launching to consumers, although Zuckerberg said some external developers will be able to get them. It'll be the next version, however, that the company eventually launches to the public.

But beyond "Orion," Zuckerberg also announced a limited-edition frame of Meta's Ray-Ban glasses and a slew of updates to the sleeper hit, along with new celebrity voices for its Meta AI chatbots as well as multi-modal features.

Zuck covered some of the big names behind Meta AI's voices, demonstrated some impressive real-time assistance tools, and debuted a new entry-level Quest 3S that costs \$299.

It was a chance for Zuckerberg to outline his vision of the future — and Meta's role in shaping what could be the next big computing platform.

Wall Street seemed impressed. Meta's stock was up more than 2% as Zuckerberg exited the stage.

Scroll on to get the full recap of his intro at Meta Connect 2024.

See more

Meta Ray-Bans. Meta© Meta

- Meta's Ray-Ban smart glasses are getting an upgrade with new AI features and memory retention.
- The glasses can scan QR codes, give live assistance in the moment, and offer live translations.

- Mark Zuckerberg touted the new functions at Meta Connect 2024.

Meta's smart glasses are getting an upgrade.

Mark Zuckerberg, the CEO of the tech behemoth, shared the updates to Meta's Ray-Bans during the company's annual show-and-tell conference, [Meta Connect 2024](#).

"We can start to see how the future of computing and the future of human connection are going to look, and it's pretty awesome," Zuckerberg said, touting Meta's smart glasses, mixed reality, and AI. "People love their Ray-Ban Meta glasses so much so that for a little while, we were struggling to keep up with the demand."

The updated glasses will retain memories of what users see and remind them about it later, helping them remember things like what they need to buy, Zuckerberg said.

"If you're heading somewhere, no more forgetting where you parked. Your glasses have you covered, and they can also remind you to pick up some avocados at the store," he said.

The glasses will also be able to scan QR codes, include video functionality with Meta AI for better in-the-moment assistance, and have live language translations between English and French, Italian, and Spanish using AI automatic dubbing.

"We are also adding multimodal video AI, so Meta AI is now going to be able to give you real-time help as you are doing things, like trying to figure out what outfit you want to wear for a party you are going to," Zuckerberg said. "There's a lot to build out over this to make it more useful over time, but this is gonna be a big platform."

The glasses will also include a new array of Transitions lenses from Ray-Ban maker EssilorLuxottica. The Ray-Ban Meta Wayfarer with polarized lenses costs \$329, while the Transitions options are \$379, according to Meta's website. There's also a limited edition transparent-framed pair of glasses available for \$429 for customers who want to "appreciate what makes them special" instead of hiding the tech within, Zuckerberg said.

"They're also just good-looking glasses. The reality is that most of the time, you're not using smart functionality," Zuckerberg said. "People want to have something on their face that they're proud of, that looks good, that's designed in a very nice way."

The existing models of [Ray-Ban Meta glasses](#) let customers capture photos and videos, live stream on Instagram, and accept video calls. The glasses have an LED light that emits a flash when a photo or video is taken to inform others nearby that they could be recorded. Still, users have figured out how to [tape over the light to record](#) surreptitiously. Meta has said this is a violation of its terms.

Last September, the tech giant announced it was adding Meta AI to its smart glasses for US-based customers, letting them use the virtual assistant AI with the command, "Hey Meta." Zuckerberg touted this feature in an Instagram video where he used the AI to walk him through [braiding his daughter's hair](#).

Business Insider's Jordan Hart [tried out the smart glasses](#) at the time and noted that the photo capture function is reminiscent of using a disposable camera thanks to the LED flash. Photos turned out dark in low-light settings and blurry even with better lighting. The lenses don't have an AR display, so images have to be reviewed using the Meta View app on a smartphone.

Meta isn't redesigning its increasingly popular [Ray-Ban Meta Smart Glasses](#), but it is pouring attention on them in the form of new colors, faster transition lenses, and a lot more Meta AI capabilities.

At Meta Connect 2024 at the Meta Headquarters in Menlo Park, California, I got a chance to try out the smart glasses' latest capabilities, and it's clear to me that this little brain transplant will help raise Ray-Ban Meta's wearable companion capabilities.

Most of my experiences were in a sample Ray-Ban Meta Pop-up store, the first of which will soon appear in Los Angeles. It's a place where you can experience all of the smart glasses' various features, including Meta AI-powered ones, buy glasses, and even get them personalized with a custom engraving.

Some of Meta AI's updated capabilities are thanks to better third-party app integrations. Meta AI can now play Spotify Music, and the requests can be based on artists, tracks, or even moods.

Sing a song

I donned a tortoiseshell pair of Ray-Ban Metas and asked Meta AI to play me a happy song by Taylor Swift. Granted, that was a bit of a fumbled request, so I guess I wasn't surprised when Meta started playing the Happy Birthday song through the smart glasses' speakers, which are positioned in the stems and near my ears.

I regrouped and asked for a Taylor Swift song (I know, shockingly not *Hot to Go* by Chappell Roan), and after a second delay, it played Shake It Off.

Meta AI now has vision capabilities, so there were places throughout the demo store where I could look at things and ask Meta AI what I was looking at.

There was an LA city street diorama in the middle of the store. I looked at it and asked Meta AI using the prompt, "Hey, Meta" what I was looking at. It took a few moments for Meta AI to reply, and I thought it didn't hear me, but then it finally said, "You're looking at a diorama featuring various cars and palm trees," which was accurate.

With Meta AI, Ray-Ban Meta Smart Glasses also have some basic translation capabilities. I looked at a Spanish-language sign in the pop-up store and ask Meta AI to "translate this sign." I heard the smart glasses take a picture (it sounds like a camera shutter), and then Meta AI said, "Flower market, Mercado De Flores." I thought the Spanish pronunciation at the end was a nice touch.

You can also use Meta AI to set visual reminders, though it's a kind of clumsy process where you look at something and then tell Meta AI to remind you to do something later. I asked it to remind me to buy a book in five minutes. It might be just as quick to take out your phone and put in a reminder, but if you're in the habit of doing this a lot, using Ray-Ban Meta and Meta AI might be a time saver.

We also used Meta AI to read a QR code and send the link to a phone, and I spotted some people in the corner of the room getting their glasses engraved. One cool little demo was Ray Ban Meta's improved transition lenses. I watched as a Meta employee used a blue light to turn lenses a nice, dark shade quickly. I didn't even know blue light could do that.



((Image credit: Future))

Ray-Ban Meta Wayfarer Smart Glasses still start at \$329. Remember that not all of Meta AI's features (like Vision) are available worldwide, so check before you buy this wearable companion.

Look Ma, all hands!

Meta is reportedly gearing up to announce a cheaper version of its [Meta Quest 3](#) headset at next month's Meta Connect event: the [Meta Quest 3S](#). The Quest 3S is said to be a similarly specced headset with a mix and match of Quest 3 performance and Quest 2-like style and build.

However, to keep the headset's price down, [Meta is reportedly looking to ship the device without any controllers](#), trusting that its hand-tracking tech will be enough for most users to get by.

According to The Information, Puffin will likely follow suit, adopting eye and hand-tracking to interact with VR/AR elements similar to that found within Apple's Vision Pro.

Smart glasses are already here: Why wait for 2027?

As impressive as Meta's proposed Puffin headset/smart glasses hybrid sounds, what's more impressive is the fact that a similar experience already exists in [XREAL's Air 2 Ultra AR smart glasses](#).

While it may not have the pancake lenses of Meta's Puffin, the Air 2 Ultra provides fairly expansive AR viewports via a micro-OLED projection, reflected off of a secondary lens (with a 52-degree field of vision) which delivers full 3D, 1080p augmented reality displays.

Better still, this model of XREAL's impressive Air 2 AR glasses also features hand and head tracking with spatial anchoring for a full six degrees of freedom, depth mesh, plane detection, and image tracking to further the frame's AR potential.

XREAL's AR smart glasses are also tethered, typically connecting to any DisplayPort over USB-C compatible smartphone, tablet, or laptop. However, the company has recently released its [second-generation Beam Pro](#), which is a smartphone-esque device that offers a pocket-sized spatial computing experience while providing a decent level of battery to keep the frames running for longer.

Unfortunately, where XREAL's high-spec spectacle falls short is in their target audience, which is developers seeking to find use for this impressively outfitted wearable. However, given a year or two, we could see a plethora of software designed to unlock the potential of these smart glasses and showcase exactly what is possible in this form factor.

Outlook

Meta's ambitions for VR and AR stretch far beyond the bulky headsets we have available to us today. The success of the company's Ray-Ban Meta Smart Glasses was a surprise to many who saw Google Glass crash and burn a decade ago.

However, smart glasses are making a strong comeback, and brands like XREAL, VITURE, RayNeo, and more have been pushing the boundaries of what can be achieved in this form factor for some time now.

While one of Meta's biggest reveals during next month's Connect event could undoubtedly be the rumored "Orion" AR glasses, that's a project not expected to make its way to market for much of the remaining decade.

Project Puffin is a clear stepping stone towards that end goal and could be Meta's opening gambit in its efforts to compact the technology of its Quest headsets and expand on the potential of its smart glasses success.

For decades, scientists have been on a relentless quest to unravel the mysteries of intelligence. The intricate interplay between [brain structure](#) and functional connectivity that underlies human intelligence has remained an enigma.

However, a groundbreaking analysis has recently offered unprecedented insight into how various brain regions and neural networks contribute to a person's problem-solving abilities, shedding light on the elusive trait known as general intelligence.

Study lead author Evan Anderson. (CREDIT: L. Brian Stauffer)© The Brighter Side of News

This research, led by Aron Barbey, a distinguished professor of psychology, bioengineering, and neuroscience at the [University of Illinois Urbana-Champaign](#), in collaboration with Evan Anderson, a researcher for Ball Aerospace and

Technologies Corp. working at the Air Force Research Laboratory, provides a fresh perspective on the biological foundations of intelligence.

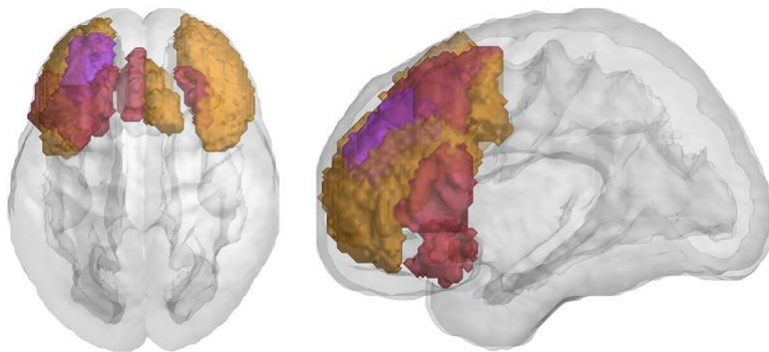
Their findings, published in the [journal Human Brain Mapping](#), offer a clearer picture of the brain's role in problem-solving and adaptability.

The study employs a novel approach known as "connectome-based predictive modeling" to explore five prominent theories about the neural mechanisms driving intelligence.

As Aron Barbey explains, "To understand the remarkable cognitive abilities that underlie intelligence, [neuroscientists](#) look to their biological foundations in the brain."

Modern theories seek to show how the brain's information-processing architecture enables problem-solving capacity. Evan Anderson elaborates on the need for a biological understanding, emphasizing the importance of "characterizing how individual differences in intelligence and problem-solving ability relate to the underlying architecture and neural mechanisms of brain networks."

Traditionally, [theories of intelligence](#) have concentrated on localized brain regions, such as the prefrontal cortex, renowned for its role in cognitive functions such as planning, problem-solving, and decision-making.



Functional regions included in the Lateral PFC connectivity map, colored by intrinsic connectivity network. Purple, ventral attention; orange, frontoparietal; red, default mode. (CREDIT: Human Brain Mapping)© The Brighter Side of News

More recent theories have shifted their focus towards specific brain networks, while others delve into the intricate interactions between different networks. Barbey and Anderson put these established theories to the test against their own "network neuroscience theory," which posits that intelligence emerges from the

global [architecture of the brain](#), encompassing both strong and weak connections.

Anderson clarifies the distinction between these connections, stating that "Strong connections involve highly connected hubs of information-processing that are established when we learn about the world and become adept at solving familiar problems."

On the other hand, weak connections, while fewer in number, provide flexibility and [adaptive problem-solving](#) capabilities. Together, these connections form the network architecture essential for tackling the diverse challenges we encounter in life.

Functional regions included in the Parieto-Frontal Integration Theory (P-FIT) connectivity map, colored by intrinsic connectivity network. Green, dorsal attention; purple, ventral attention; orange, frontoparietal; red, default mode. (CREDIT: Human Brain Mapping)© The Brighter Side of News

To evaluate their hypotheses, the research team enlisted a diverse group of 297 undergraduate students. Initially, each participant underwent a battery of comprehensive tests designed to measure problem-solving skills and adaptability across various contexts, assessments routinely used to gauge general intelligence.

Subsequently, the team collected resting-state functional MRI scans for each participant. Aron Barbey highlights the uniqueness of the human brain: "One of the really interesting properties of the human brain is how it embodies a rich constellation of networks that are active even when we are at rest." These networks constitute the biological framework of the mind and are believed to be intrinsic [properties of the brain](#).

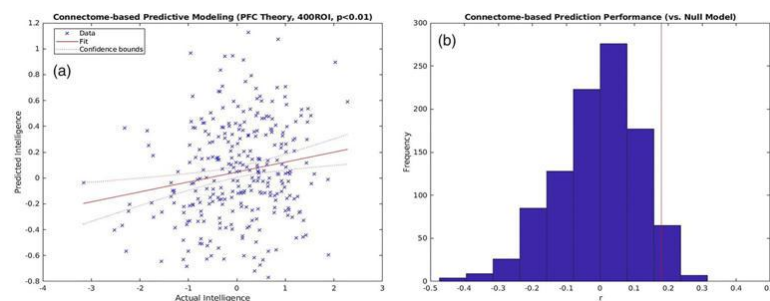
Notable among them are the frontoparietal network, responsible for cognitive control and goal-directed decision-making; the dorsal attention network, which aids in visual and spatial awareness; and the salience network, directing attention towards the most relevant stimuli.

Functional regions included in the Multiple Demand (MD) Theory connectivity map, colored by intrinsic connectivity network. Green, dorsal attention; purple, ventral attention; orange, frontoparietal; red, default mode. (CREDIT: Human Brain Mapping)© The Brighter Side of News

Previous studies have demonstrated that the activity of these networks, when an individual is awake but not engaged in a task or external stimuli, reliably **predicts cognitive skills** and abilities.

The convergence of cognitive tests and fMRI data enabled the researchers to assess which theories best predicted participants' performance on intelligence tests.

Evan Anderson explains, "We can systematically investigate how well a theory predicts **general intelligence** based on the connectivity of brain regions or networks that theory entails." This approach facilitated a direct comparison of the neuroscience predictions generated by various theories.



N-fold cross-validated performance for connectome-based predictive modeling (CPM) predictions of g using functional edges from Lateral Prefrontal Cortex (PFC) Theory. (CREDIT: Human Brain Mapping)© The Brighter Side of News

The results were unequivocal – taking into account the features of the entire brain yielded the most accurate predictions regarding an individual's problem-solving abilities and adaptability. Remarkably, this held true even when accounting for the number of brain regions included in the analysis. While the other theories also demonstrated predictive power, the network **neuroscience theory** surpassed them, excelling in multiple aspects.

The implications of these findings are profound. They illuminate the concept that "global information processing" within the brain is at the core of an individual's cognitive prowess. Rather than originating from a specific region or network, intelligence appears to be an emergent property of the **brain's global architecture**, reflecting its efficiency and flexibility in network-wide functioning.

Aron Barbey's involvement extends beyond this study. He is a faculty member in the Beckman Institute for Advanced Science and Technology, the Carl R. Woese Institute for Genomic Biology, and a professor of speech and hearing science, in

addition to being a member of the neuroscience program at the University of Illinois Urbana-Champaign.

His multidisciplinary approach underscores the significance of collaboration and innovation in unlocking the secrets of the [human mind](#).

As we delve deeper into the intricate neural networks that underpin our cognitive abilities, we inch closer to unraveling the profound mysteries of human intelligence, opening doors to enhanced problem-solving, adaptability, and the potential to unlock the full capabilities of the human mind.

As you travel your usual route to work or the grocery store, your brain engages cognitive maps stored in your hippocampus and entorhinal cortex. These maps store information about paths you have taken and locations you have been to before, so you can navigate whenever you go there. New research from MIT has found that such mental maps are also created and activated when you merely think about sequences of experiences, in the absence of any physical movement or sensory input.

In an animal study, the researchers found that the entorhinal cortex harbors a cognitive map of what animals experience while they use a joystick to browse through a sequence of images. These cognitive maps are then activated when thinking about these sequences, even when the images are not visible.

This is the first study to show the cellular basis of mental simulation and imagination in a nonspatial domain through activation of a cognitive map in the entorhinal cortex.

"These cognitive maps are being recruited to perform mental navigation, without any sensory input or motor output. We are able to see a signature of this map presenting itself as the animal is going through these experiences mentally," says Mehrdad Jazayeri, an associate professor of brain and cognitive sciences, a member of MIT's McGovern Institute for Brain Research, and the senior author of the study.

McGovern Institute Research Scientist Sujaya Neupane is the lead author of the [paper](#), which appears in *Nature*. Ila Fiete, a professor of brain and cognitive sciences at MIT, a member of MIT's McGovern Institute for Brain Research, director of the K. Lisa Yang Integrative Computational Neuroscience Center, is also an author of the paper.

Mental maps

A great deal of work in animal models and humans has shown that representations of physical locations are stored in the hippocampus, a small seahorse-shaped structure, and the nearby entorhinal cortex. These representations are activated whenever an animal moves through a space that it has been in before, just before it traverses the space, or when it is asleep.

"Most prior studies have focused on how these areas reflect the structures and the details of the environment as an animal moves physically through space," Jazayeri says. "When an animal moves in a room, its sensory experiences are nicely encoded by the activity of neurons in the hippocampus and entorhinal cortex."

In the new study, Jazayeri and his colleagues wanted to explore whether these cognitive maps are also built and then used during purely mental run-throughs or imagining of movement through nonspatial domains.

To explore that possibility, the researchers trained animals to use a joystick to trace a path through a sequence of images ("landmarks") spaced at regular temporal intervals. During the training, the animals were shown only a subset of pairs of images but not all the pairs. Once the animals had learned to navigate through the training pairs, the researchers tested if animals could handle the new pairs they had never seen before.

One possibility is that animals do not learn a cognitive map of the sequence, and instead solve the task using a memorization strategy. If so, they would be expected to struggle with the new pairs. Instead, if the animals were to rely on a cognitive map, they should be able to generalize their knowledge to the new pairs.

"The results were unequivocal," Jazayeri says. "Animals were able to mentally navigate between the new pairs of images from the very first time they were tested. This finding provided strong behavioral evidence for the presence of a cognitive map. But how does the brain establish such a map?"

To address this question, the researchers recorded from single neurons in the entorhinal cortex as the animals performed this task. Neural responses had a striking feature: As the animals used the joystick to navigate between two landmarks, neurons featured distinctive bumps of activity associated with the mental representation of the intervening landmarks.

"The brain goes through these bumps of activity at the expected time when the intervening images would have passed by the animal's eyes, which they never did," Jazayeri says. "And the timing between these bumps, critically, was exactly the timing that the animal would have expected to reach each of those, which in this case was 0.65 seconds."

The researchers also showed that the speed of the mental simulation was related to the animals' performance on the task: When they were a little late or early in completing the task, their brain activity showed a corresponding change in timing.

The researchers also found evidence that the mental representations in the entorhinal cortex don't encode specific visual features of the images, but rather the ordinal arrangement of the landmarks.

A model of learning

To further explore how these cognitive maps may work, the researchers built a computational model to mimic the brain activity that they found and demonstrate how it could be generated. They used a type of model known as a continuous attractor model, which was originally developed to model how the entorhinal cortex tracks an animal's position as it moves, based on sensory input.

The researchers customized the model by adding a component that was able to learn the activity patterns generated by sensory input. This model was then able

to learn to use those patterns to reconstruct those experiences later, when there was no sensory input.

"The key element that we needed to add is that this system has the capacity to learn bidirectionally by communicating with sensory inputs. Through the associational learning that the model goes through, it will actually recreate those sensory experiences," Jazayeri says.

The researchers now plan to investigate what happens in the brain if the landmarks are not evenly spaced, or if they're arranged in a ring. They also hope to record brain activity in the hippocampus and entorhinal cortex as the animals first learn to perform the navigation task.

"Seeing the memory of the structure become crystallized in the mind, and how that leads to the neural activity that emerges, is a really valuable way of asking how learning happens," Jazayeri says.

More information: Mehrdad Jazayeri, Vector production via mental navigation in the entorhinal cortex, *Nature* (2024). DOI: [10.1038/s41586-024-07557-z](https://doi.org/10.1038/s41586-024-07557-z). www.nature.com/articles/s41586-024-07557-z

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Provided by Massachusetts Institute of Technology

Scientists found the molecule KIBRA works with PKMzeta to form long-term memories by tagging certain synapses, opening potential for memory-related therapies. © Jonathan Knowles - Getty Images

- Scientists have long known that the molecule protein kinase Mzeta (PKMzeta) plays a central role in forming memories.
- Now a new study identifies its partner-in-crime, another molecule named kidney and brain expressed adaptor protein (KIBRA), which forms

long-term memories through interactions that “tag” certain synapses in neurons.

- Further study of this interaction could help scientists develop therapies in relation to memory.

Famous Irish poet, author, and playwright Oscar Wilde once wrote that “memory is the diary we all carry about with us,” but the biological author of this lifelong memoir is far from certain. In the 1970s, scientists discovered long-term potentiation (LTP), which detailed how strengthening and weakening synapses helped form [memory](#), but that’s only part of the story.

In order to pull off this wondrous feat, synapses rely on a variety of molecules to form certain types of memories. One of these is PKMzeta (protein kinase Mzeta), which, when inhibited in the brains of rats [during a 2006 experiment](#), caused disruption in spatial memory in the hippocampus. So there you go. Problem solved, right? Well, as you might imagine, when it comes to understanding the inner workings of [the human brain](#), things are bit more complicated.

One of the big drawbacks of relying on PKMzeta to be *the* molecule responsible for memory formation is that it simply doesn’t last in the [brain](#) very long, sticking around for only a couple hours or days. Humans likely wouldn’t have invented agriculture let alone launch rockets into space with such subpar recall. Also, with 10,000 synapses to every one neuron, scientists didn’t know exactly how PKMzeta strengthened some synapses and not others.

Now, a new study from scientists at the State University of New York (SUNY) Downstate Health Sciences University has an answer for those long-standing questions. It turns out PKMzeta gets a little help from a friend—in this case, another molecule known as the kidney and brain expressed adaptor protein, known as KIBRA. The results were published in the journal [Science Advances this past June](#).

“During memory formation the synapses involved in the formation are activated,” SUNY’s Todd Sacktor, senior author of the study, [said in a press statement](#), “and KIBRA is selectively positioned in these synapses. PKMzeta then attaches to the KIBRA-synaptic-tag and keeps those synapses strong. This allows the synapses to stick to newly made KIBRA, attracting more newly made PKMzeta.”

The researchers call this KIBRA the “missing link” molecule that acts as a glue that allows memories to persist for years or even decades. The study analyzes these molecules in laboratory mice and found that blocking this molecular interaction disrupted spatial memory, and while both molecules are short-lived, their interaction persists.

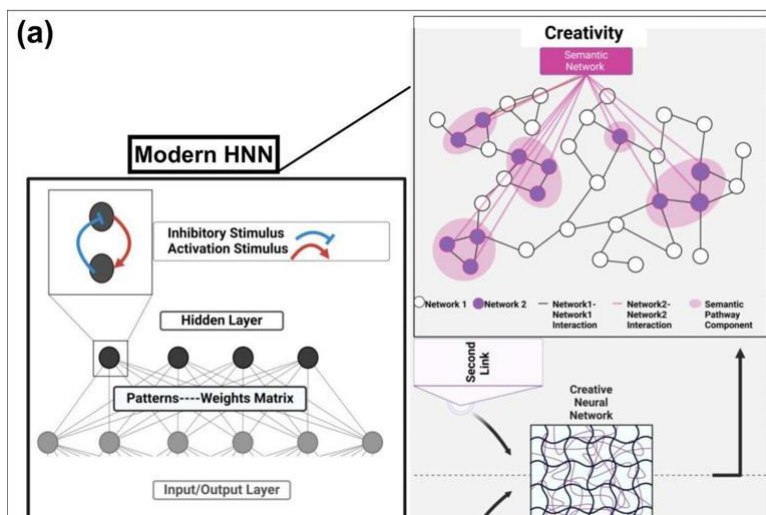
Sacktor [references a 1984 hypothesis](#) by Francis Crick, the co-discoverer of DNA, that described the [creation of memories](#) as “molecular turnover.” Sacktor compares the idea to the famous philosophical concept known as the [Ship of Theseus](#), which asks whether a ship that’s been repaired so frequently that not even the keel is original is still the same ship that first left port. Similarly, Sacktor says, PKMzeta and KIBRA could work together to create long-term memories.

“The persistent synaptic tagging mechanism we found is analogous to how new planks replace old planks to maintain Theseus’s Ship for generations,” Sacktor said in a press statement, “and allows memories to last for years even as the proteins maintaining the memory are replaced. Francis Crick intuited this Theseus’s Ship mechanism, even predicting the role for a protein kinase. But it took 40 years to discover that the components are KIBRA and PKMzeta and to work out the mechanism of their interaction.”

Exploring the interactions of these two molecules opens a world of possibilities, some of which are decidedly sci-fi.

“I’m seeing more and more the possibilities of directly putting proteins in neurons through gene therapy,” Sacktor [told *Scientific American*](#), which would theoretically strengthen fading memories. But for now, memory wiping like some sort of *Harry Potter* spell or *Men in Black* gadget—pick your favorite cultural reference—are a bit more far-fetched. “If you wanted to use this sort of mechanism to target unwanted memories—which creates ethical issues anyways—you’d have to find a way to make it specific to certain memories.”

True to Wilde’s words, memory might be the diary we carry with us—but in the future, who says we can edit a few chapters?



Summary of a hypothetical model of the simulation of the modern Hopfield neural network. Credit: The Journal of Creative Behavior (2024). DOI: 10.1002/jocb.680

Creativity is the art of combining diverse ideas, making meaningful

connections between concepts, and remaining focused to produce innovative ideas and useful solutions. Expansive and remote associations drive the generation of new ideas, while inhibition enables refining these ideas into practical solutions.

A recent study, led by former student Ronald Mtenga and directed by Dr. Mathias Bode and Dr. Radwa Khalil at Constructor University, has illuminated crucial conclusions about creative thinking processes. The [study](#), published in the *Journal of Creative Behavior*, provides a fresh perspective on the shift from analytical to creative thinking.

This study employed a unique approach by utilizing the Hopfield neural network (HNN), a neural network model, to investigate the mechanisms of semantic creative thinking–based associations. Researchers identified two key mechanisms that facilitate the transition from analytical to creative, associative thinking, suggesting that creative thinking often emerges when analytical thinking is insufficient.

Ronald Mtenga, the study's first author, holds a BSc in Electrical and Computer Engineering from Constructor University, where Dr. Mathias Bode is affiliated. Dr.

Radwa Khalil is an expert in the creativity field, known for her multidisciplinary approaches that spans cognitive neuroscience, neuropsychology, computational modeling, and empirical research.

More information: Ronald Mtenga et al, Do Not Let the Beginning Trap you! On Inhibition, Associative Creative Chains, and Hopfield Neural Networks, *The Journal of Creative Behavior* (2024). DOI: [10.1002/jocb.680](https://doi.org/10.1002/jocb.680)

Provided by Constructor University

Meta Connect 2024 recap: Mark Zuckerberg reveals Orion smart glasses, new AI features, transparent Ray-Bans, and an affordable Quest 3S

©Getty/picture alliance

- Mark Zuckerberg kicked off the Meta Connect 2024 developer conference on Wednesday with a keynote.
- The big news was his demo of Meta's first "true AR" prototype glasses, "[Orion](#)," which are still a work in progress.
- He also revealed new Meta AI features, limited-edition Ray-Ban smart glasses, and a \$299 Quest 3S.

[Mark Zuckerberg](#) knocked it out of the park during Meta's big day.

The [Meta](#) CEO took the stage on Wednesday to announce a slew of new AI and hardware products — including a teaser of the company's long-awaited fully holographic glasses, Orion.

The Orion glasses were the news of the day, and in a surprising turn for AR glasses, they looked ... pretty slick!

The smart glasses integrate visuals into the lenses, making them the company's first "true AR" glasses. Notably, they appeared sleeker than the new [Snap Spectacles](#) that Snap CEO Evan Spiegel showed off last week. Of

course, they still have a ways to go until they truly blend in like Meta's Ray-Ban smart glasses.

Zuckerberg ran a sizzle reel of famous names in tech reacting positively to the Orion glasses, from Nvidia CEO Jensen Huang to Reddit CEO Steve Huffman praising them as a leap forward.

Business Insider's chief correspondent, Peter Kafka, also got an [early demo of Orion](#) and wrote that he'd "buy them in a heartbeat." But people will have to wait a while to get their hands on the AR glasses.

The current Orion prototype isn't launching to consumers, although Zuckerberg said some external developers will be able to get them. It'll be the next version, however, that the company eventually launches to the public.

Zuckerberg's other announcements were more tangible. He showed off limited-edition frames of Meta's Ray-Ban glasses and a slew of feature updates to the sleeper hit, along with new celebrity voices for its Meta AI chatbots and multi-modal voice and vision features.

The CEO covered some of the big names behind the new Meta AI voices, which range from John Cena to Awkwafina, and he demonstrated some impressive real-time assistance tools and debuted a new entry-level Quest 3S mixed-reality headset that costs \$299.

The keynote was a chance for Zuckerberg to outline his vision of the future — and Meta's role in shaping what could be the next big computing platform.

Wall Street seemed impressed. Meta's stock was up more than 2% as Zuckerberg exited the stage.

Scroll on to get the full recap of Zuckerberg's Meta Connect keynote.

That's a wrap! Zuckerberg closes out his keynote with a glimpse into the AI future.

Zuckerberg has been all about the future of tech, and the conclusion of his keynote is no different.

His segment of the Connect keynote concluded with a skit about how the Orion smart glasses could one day transform how humans communicate today.

We're seeing what his vision is when the technology catches up, with holographic conversations with others that make it feel like your friend is in the room with you.

Filmmaker Matthew Vaughn also briefly takes the stage to say how impressed he was by Orion.

And that's it for Zuck's 2024 Meta Connect keynote!

Zuckerberg says the public will have to wait to get their hands on full holographic glasses.

Zuckerberg said that the Orion holographic glasses aren't quite ready to hit the shelves for consumers, but they'll be available for some external developers.

In the meantime, Zuckerberg said Meta is working on lowering the retail price for the glasses and work on manufacturing challenges.

So it'll be the next version of the glasses that Meta will eventually launch as a consumer pair — release date TBD.

Nvidia CEO Jensen Huang was among those who tested out the 'Orion' glasses early.

Zuckerberg says that early testers of the Orion glasses were left "giddy" by what the device could do.

He rolls a video of various big names in tech and Silicon Valley trying them out early.

Nvidia CEO Jensen Huang was among the tech CEOs, media personalities, and Olympians who praised Orion — calling its 100-gram weight "a big deal" and praising the visuals and field of view.

Zuck's vision for the AI future includes a "neural interface."

"I think that you need a device that allows you to send a signal from your brain to the device," Zuckerberg said.

As such, the glasses come with a bracelet that makes that possible.

Zuckerberg says Orion will be used as a "dev kit" — so don't expect to be able to buy it anytime soon.

We're getting our first look at Orion, the "full holographic" glasses prototype.

There's a bit of theatrics to introduce the bulky eyewear — they're brought in under lock and key in a briefcase.

Zuckerberg shows off "Orion," fully holographic glasses that he says are the most advanced device of their kind.

Zuck drops limited-edition Ray-Ban glasses.

To top off the new updates to Meta's Ray-Ban glasses, Zuckerberg said the tech giant would launch a pair of limited-edition clear-frame glasses.

The smart glasses will also be a real-time translator.

©Meta

Zuckerberg said that Meta AI will be able to translate conversations live for those wearing their smart Ray-Ban glasses, and he demonstrated as much by carrying out a conversation in Spanish onstage with Brandon Moreno.

The glasses will translate in your ear what someone is saying, and your responses can be translated via the companion app.

Now here's what's new with Meta's Ray-Ban smart glasses.

Meta's Ray-Ban smart glasses are getting more conversational, and they'll have a better memory of what you've seen, Zuckerberg said.

They will also be outfitted with multi-modal AI that has the power to assist users in real time.

We're seeing some upcoming features, like the AI offering fashion advice based on what it sees you grabbing to put on as you get ready for a night out.

The next demo is a bit uncanny.

Meta is expanding its AI creator tools.

Technologist Don Allen Stevenson III joined Zuckerberg onstage to demonstrate a video calling feature during which he spoke to an AI version of Stevenson.

An AI avatar who looked and sounded like Stevenson answered questions about his creative process.

In another demonstration, creators speaking in one language could use AI to dub their videos in a new language.

Natural voices are the 'biggest AI' announcement of the day.

According to Zuck, interacting with AI using your voice will be a better way to interact with AI than text.

To demonstrate, Zuckerberg quickly asked a Meta AI assistant a question, and the chatbot responded with the voice of actor Awkwafina.

Meta is adding a bunch of celeb voices to its AI models that you can choose from, including Dame Judi Dench, John Cena, Keegan Michael Key, and Kristen Bell.

Here's some new Quest features.

Zuck mentions a partnership with Microsoft to allow seamless use of a Windows PC while on the Quest.

And in the Metaverse, avatars have gotten a makeover and portals that allow users to jump around worlds will be available.

Hyperscape is another new feature for Quest users. It allows users to create photo-realistic spaces to virtually explore with photos.

He jumps "right in" with a demo in the crowd.

We're getting a quick demo right away to test out the improved pass-through abilities found on the Meta Quest 3S, which Zuckerberg says will make mixed-reality better.

We're seeing a lot of Apple Vision Pro-like examples of someone with floating panels of content in front of them, hovering in the air. You can also stick the virtual panels to the nearby wall.

Zuckerberg starts off the keynote with a new Quest 3S headset.

"It's been a busy year. It's been an exciting year," Zuckerberg said.

He then jumped right in with a new \$299 Quest 3S, an entry-level mixed-reality headset.

CTO Andrew Bosworth is pulling up to Meta Connect in style.

Meta CTO Andrew Bosworth, also known as Boz, is expected to be among the main speakers at the Connect keynote on Wednesday afternoon.

Less than an hour before the event kicks off, Bosworth shared an Instagram story sharing that he was headed to the event. From a mirror inside his futuristic Mercedes-Benz, we can see that he captured the video using Meta's Ray-Ban smart glasses.

"On my way to Meta Connect," Bosworth said in the caption.

There's been a lot of chatter around Meta's 'Orion' AR glasses.

©REUTERS/Carlos Barria/File Photo

Business Insider first reported in February that [Meta was aiming to show off and demo its first true AR glasses](#) in the fall at Connect and that the prototype was referred to internally as "Orion."

Publicly, Zuckerberg hasn't held back from teasing that a new pair of AR glasses are in the works. A February photo on [Threads](#) was called out this summer for having a pair of mystery glasses in the background.

The Meta CEO responded to the question about the glasses with, "Will be ready to share more later this year."

The Connect keynote could be the time to officially introduce the public to these glasses, which are reportedly separate from the Meta Ray-Ban's, which don't feature a screen in the lenses, and the bulkier Quest headset, which is all about the VR screens and AR passthrough cameras. The "Orion" AR glasses, which are expected to integrate visuals into the lenses, aren't expected to go on sale in the near term — but seeing them demoed would offer an interesting glimpse into where Meta envisions the future of AR glasses is headed.

Zuckerberg said in an interview earlier this year that the Orion glasses won't be as stylish and slim as the Meta Ray-Ban product.

I tried Meta's Orion computer glasses, and they are very cool. Meta

- Mark Zuckerberg has unveiled Orion, Meta's new augmented-reality glasses.
- Lots of people think these kinds of glasses could be the future of computing — as powerful as an iPhone, but something you can wear on your head.
- But Meta says these are too expensive for the mass market. It will take years to make them smaller and cheaper.

Here is what you need to know about Orion, the new computer-on-your-face [nerd](#) glasses [Mark Zuckerberg](#) showed off today:

1. You can't buy them. And you won't be able to anytime soon. It's possible you never will.

Each pair of glasses reportedly costs [Meta](#) \$10,000 to make, and the company says it needs time to get them to a price that makes them plausible — think something in the \$1,000-ish range, like a laptop or high-end phone. (That \$10,000 number [comes from The Verge's Alex Heath](#). Meta declined to comment on the number).

If all goes well, it could take a few years for that to happen.

2. I've tried them, and they are very cool!

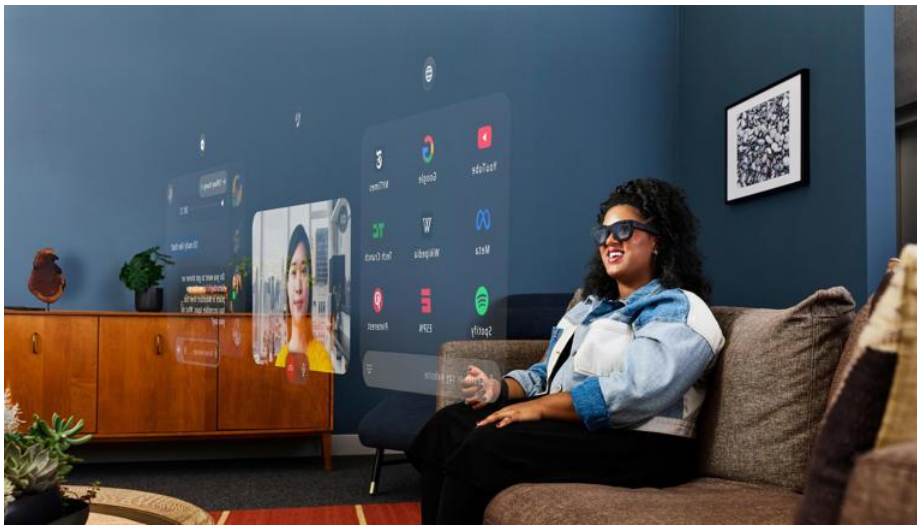
They don't make you *look* cool — you look like someone wearing tech on your face — but the ideas and engineering behind them are really fascinating. If you're one of the people who complains that Silicon Valley hasn't made anything except soul-sucking social networks and monetization machines for years, here's a compelling counter.

More important: Unlike other face-computing tech I've tried over the years — [Google's Glass](#), Apple's [Vision Pro](#), Meta's own line of Quest goggles — this is one I can actually imagine buying, and using, in real life.

My brief experience with [Orion](#) comes with major caveats. The biggest is that it's not actually ready for mass production. But if this pans out, it will deliver what lots of people in tech, and outside tech, say they want: a wearable computer jammed into a pair of glasses.

What would you do with a wearable computer?

For starters, lots of things you can do with a phone: Take and make phone calls and video calls. Send and receive texts. Take photos and videos. Watch videos. Play time-wasting games. Play around with AI.



Meta's Orion glasses can serve many of the same purposes as a smartphone. Meta© Meta

And because Orion sits on your face like glasses — bulky glasses that use silicon carbide instead of glass — you can do all those things while looking at, and interacting with, everything and everyone around you.

This is "[augmented reality](#)" — digital images laid over the real world. As opposed to "virtual reality" — where you are totally enveloped by a digital landscape.

There are obvious downsides to this. If you think it's frustrating to talk to someone who keeps looking at their phone to check a text or a viral video, imagine what it will be like to hold a conversation with someone who's staring at you and staring at something else at the very same time.*

But there are very intriguing upsides, too. Most obviously: Picture yourself with a task — like changing a tire, making marinara, or solving a math problem — and

the ability to simultaneously look at the thing you want to do and instructions on how to do it.

Orion uses eye tracking, which means you select digital items just by looking at them. And you manipulate them — turn an app on or off, respond to a text message, swipe through videos on [Reels](#) — by making subtle flicks and clicks with your fingers. Those gestures get registered by a snug-but-not-bulky wristband** that registers your muscles' movements using [electromyography](#)*** and transmits them wirelessly to your glasses.



Meta's Orion glasses are connected to a wristband that reads muscle movements. Meta© Meta

Orion also comes the closest I've seen to a face computer you could take for a stroll. Unlike other devices I've seen, it doesn't need to be plugged into a [bulky power source](#) or tethered to a phone. Instead, it connects wirelessly to a TV-remote-sized power/computing device you can slip into your pocket that connects to the internet via WiFi or cell signals. Meta says its battery will last for two to three hours of continual use.

And here, I'm going to stop talking about Orion's specs. Because it seems pretty silly to get very deep into a thing that's still in development and may never actually materialize for mass production.

It's also important to stress that my brief demo time was in a Meta building, surrounded by Meta employees who guided me through a Meta-scripted walk-through. I have no idea how, or if, this thing works in the real world.

Neither do Meta executives, really. They say they're about to start "dogfooding" the device with lots of employees to get a better sense of how it performs while continuing to figure out how to make it lighter and cheaper.

Which brings us to two questions about Zuckerberg's reveal this week.

First: Why is Meta showing off something no one's going to be able to buy — at best — for years? This reminds me of pre-iPhone reveals, where it was common for tech companies to show you stuff they *might* make one day, but very often didn't.

When I ask Meta executives that question, they murmur about wanting their fellow employees to see the work they're doing, and to be encouraged by the progress they're making. But surely there are other ways to pump up morale — like having a [record-high stock price](#), which happens to have happened this week.

My theory relates to that stock price: that Zuckerberg, who has gotten grief over the years for plowing billions into his [metaverse dreams](#), wants to show the world — and specifically investors — that all those dollars weren't wasted. And that he's getting very close to a consumer device people might buy in very large numbers.

Which brings us to my second question: Why does Meta, whose online ad business is one of the world's greatest money-printing machines, want to make hardware anyway?

That one is easier to answer. Most practically: As great as that money-printing machine is, it can't work without phones made by [Apple](#) and Google — companies that force Meta to play by their rules and restrictions. If Orion, or any other device Meta makes, becomes the future of computing, then Zuckerberg can operate *his* business on *his* devices.

But if you're into vibes-based answers: Orion's debut is part of the [Mark Zuckerberg 3.0 era](#).

One where he says he's [done apologizing](#) (even though he's [still apologizing](#)) and [done with politics](#) (even though [politics is not done with him](#)). One where he's trying [new looks](#) (including [his own designs](#)).

So if he wants to take a victory lap with very cool new tech — even if the tech isn't quite ready for prime time? He's going to do that, too.

*The entire time I played with Orion, I kept thinking about teenagers I see walking around with a [single AirPods in their ear](#) at all times. The idea, supposedly, is that they can keep listening to whatever they want while begrudgingly listening

to you, too. I find that half-in, half-out way of interacting with the world incredibly frustrating. But I'm old. Your mileage may vary.

**For whatever reason, some Meta people call this a "neural wristband," which makes it seem like it's somehow reading your brain. Thankfully, it is not.

Meta CEO Mark Zuckerberg showed off a flurry of new AI and mixed reality products, including a future version of holographic glasses, at the [company's annual Connect developer conference](#) on Wednesday, as the social media company seeks to stay ahead amid an industry-wide race to define the next phase of computing.

Zuckerberg showed off a prototype of its Orion holographic smart glasses that allow users to see digital objects overlaid over the real world and which he said can be controlled with brain waves through a "neural interface."

The glasses are not currently available, and Zuckerberg did not provide a specific time frame on when they might be available or at what price. The prototype provides a glimpse of the future that the company is working toward, he said.

The holographic smart glasses use an entirely new type of display, Zuckerberg said as he donned them. "This is not pass-through, this is the real world with holograms overlaid on it," he said.

The glasses "do voice and AI, hand and eye-tracking, but theres one more way you'll be able to interact with the that's pretty neat – neural interface – send a signal from you brain to the device," Zuckerberg said.

In a bit of theatrics scripted for the audience of Meta software developers and partners, the glasses were brought on stage in a silver metal briefcase handcuffed to the bearer's wrist.

Mark Zuckerberg unveils new Orion holographic smart glasses with a 'neural interface'

The Orion glasses, which have proven to be a [technical challenge for the company's engineers](#), would represent a major leap forward for Meta, which currently offers a far more limited type of "smart glasses" device. Meta showed

off updates to the popular, [existing RayBan smart glasses](#) that it makes and sells through a partnership with eyewear giant [EssilorLuxottica](#). These glasses don't have mixed reality features but have voice-based AI capabilities that can do real time language translation, as well as take notes and make reminders for users, such as remembering a parking space number.

Celebrity AI voices

Meta has invested tens of billions of dollars in recent quarters as it builds out its computing infrastructure to support a new generation of compute-intensive generative AI models amid [intense competition from Google and Microsoft](#). And the company has integrated its AI tools across its portfolio of internet apps including Instagram, [Facebook](#), and Whatsapp.

Nearly 500 million users now use Meta's AI products, Zuckerberg said, claiming that Meta AI is on track to be the most used AI in the world. The company rolled out new features for its AI products, including voices of celebrity actors including Awkwafina, John Cena and Dame Judi Dench. And it announced the next version of its Llama large language model, Llama 3.2, which the company said can understand both images and text.

Clad in a black T-shirt and dark, slim cut jeans highlighting [a recent image makeover](#), Facebook's 40-year old founder touted the progress at the company which now employs more than 70,000 workers and supports more than 3.27 billion users on its various products every day.

"It's been a very busy year. A lot of the stuff we've been talking about for a long time – it's happening – we can start to see how the future of computing, human connection are gonna look and it's pretty awesome," Zuckerberg said.

Among some of the other products unveiled Wednesday: a new, \$299 version of the Quest mixed reality headset.

Between and around the billions of neurons in the human brain is an equally vital scaffold, the extracellular matrix (ECM). An interlinked net of proteins and sugars that surrounds brain cells, the ECM is more than simple structural support; changes in the ECM can regulate complex brain functions including memory, learning, and behavior. But studies of the brain's ECM have been limited by the lack of tools to observe dynamic changes to its structure.

Now, a new genetic labeling tool developed by University of Utah Health researchers Igal Sterin, Ph.D., and Sungjin Park, Ph.D., has revealed new patterns in brain ECM in mice, including differences in the amount of matrix deposited on different types of neurons. A major advantage of the tool is that it can detect changes in the ECM over time, giving new insights into how the brain develops.

The research is [published](#) in *The Journal of Neuroscience*.

The new tool has two main parts: a protein that binds to the main ingredients of the brain ECM, fused to another protein that irreversibly sticks to a variety of synthetic fluorescent dyes. When scientists introduced the tool into neurons, it bound to the surrounding matrix; then, they added a fluorescent dye to make matrix structures visible. Using this tool, the researchers were able to watch as ECM was deposited over time in cultured rodent brain cells, making out dense clusters of matrix that appeared on only certain neurons and at different times.

The researchers were also able to measure changes in brain ECM in mice by adding different fluorescent dyes at different times. They could infer that ECM structures that were marked by the second dye, but not the first, had developed in the time between the two dyes were added.

The scientists hope that this tool will open the door to many further studies of how the ECM contributes to brain function in complex ways. "In the brain, the ECM regulates neuronal plasticity and cognitive function, but its structural features remain poorly understood," Park says. "By using our longitudinal genetic tool to track ECM dynamics, we can visualize how neurons assemble and remodel ECM during development, cognitive processes, and aging."

More information: Igal Sterin et al, Dynamic organization of neuronal extracellular matrix revealed by HaloTag-HAPLN1, *The Journal of Neuroscience* (2024). DOI: [10.1523/JNEUROSCI.0666-24.2024](https://doi.org/10.1523/JNEUROSCI.0666-24.2024)

Image of DNA© Shutterstock

According to [NC State University News](#), North Carolina State University (NC State) and Johns Hopkins University researchers have published a paper detailing using DNA to store data and solve simple problems. Their research, called 'A primordial DNA store and compute engine,' showed that they could store a significant amount of data that requires several hundred or even thousands of SSDs today in an area no larger than a fingernail.

"You could put a thousand laptops' worth of data into DNA-based storage that's the same size as a pencil eraser," says project lead Albert Keung to NC State University News. However, aside from storing data, the team has also proven that their DNA technology could be used to solve simple sudoku and 3 x 3 chess problems.

What's interesting about this project is that the team did not just create DNA strands to theoretically store data. Instead, they created a complete computer system using organic materials, data storage and processing, and all the required underlying parts.

"You could say that Keung's team is providing the equivalent of microcircuits, and the dendricolloidal material that my team creates provides the circuit boards," Orlin Velez, one of the co-authors of the research, told NC State University News. They also collaborated with Adriana San Miguel of North Carolina State University to incorporate the DNA that stores the data and its dendricolloidal base to direct the flow of nucleic acids and reagents, which is similar to how data is moved in current electronic computers (by using the flow of electrons).

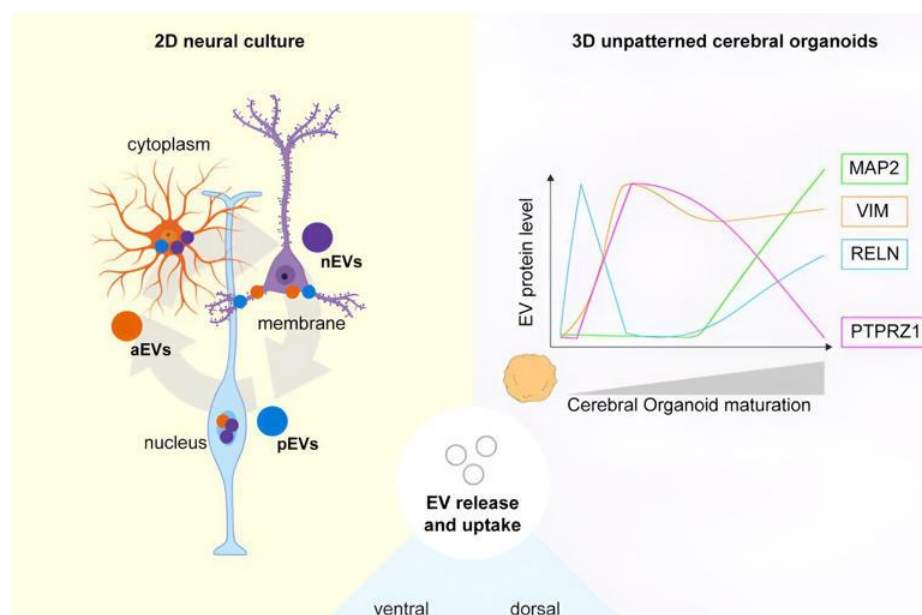
To read the stored DNA information, the team must first copy it to an RNA strand. From there, Winston Timp and their team from Johns Hopkins created a technique to read the nucleic acid sequences using nanopore sequencing. Then,

an algorithm developed by James Tuck's lab, also based in NC State, would convert the nucleic acid sequences into the data we're familiar with and vice-versa while correcting errors.

This massive collaboration has allowed NC State and Johns Hopkins teams to create the first DNA computer that can store, move, read, erase, rewrite, and reload data files. It can also do some simple computations, and, most importantly, it's programmable and repeatable.

The 'primordial DNA store and compute engine' isn't the first time engineers and scientists have attempted to use organic matter to create a computer. A research team is already planning to [build a DNA-micro factory](#) for data archives and you can even [rent a human brain organoid](#) for \$500 a month for research. However, this project is the first to implement storage *and* computing in one organic solution successfully.

Advancements like these were previously the domain of science fiction. But as humanity's data storage and computing demands grow exponentially year after year, these are slowly turning from a scientist's dream into a growing need, especially as our latest data processors consume more power. Organic computers like this could potentially make computing far more efficient and sustainable, helping us avoid a future where the face of the planet is covered by data centers and the electrical generation plants that power them.



Extracellular vesicles (EVs) are tiny bubbles released by cells, acting as cargo vessels through which cells exchange signals and thus communicate. A paper recently [published](#) in the journal *Cell Reports* has demonstrated that this form of cellular exchange also plays a key role in the development of the brain.

"Our findings underscore the central role of EVs in intercellular signaling during brain development, highlighting their potential as mediators of complex cellular interactions and as targets for future therapeutic strategies," says lead investigator Dr. Silvia Cappello, research group leader at LMU's Biomedical Center and member of the SyNergy Cluster of Excellence.

The team investigated extracellular vesicles in various model systems, including neural progenitor cells, neurons, astrocytes, brain organoids, and patterned spheroids, each derived from pluripotent stem cells. In this way, the researchers obtained various new insights into how the little transport bubbles influence brain development.

A key finding of the study is that extracellular vesicles facilitate specialized communication between different cell types. "We demonstrated that recipient cells take up cargo from different donor cells, for which they have unique patterns of uptake," explains Cappello. This highlights the specificity of EV-mediated communication.

The researchers also discovered that the protein composition in the vesicles changes during brain development and varies among different cell populations and brain regions. "This variability suggests a tightly regulated biogenesis of the EVs that is critical for their cell type-specific functions," says Cappello.

Using high-resolution live imaging techniques, the team was also able to show that extracellular vesicles enter the nucleus of neural progenitor cells during cell division. "This finding is particularly exciting, as it indicates that EVs influence crucial cellular processes not only in the cytoplasm, but also at the nuclear level."

As the study found, the transported cargo includes proteins, but also transcription factors, such as YAP1, that are directly transferred to recipient cells

and induce rapid transcriptional changes. A particularly interesting example is the transcription factor YAP1, which is directly transported to the nucleus of recipient cells, where it induces transcriptional changes.

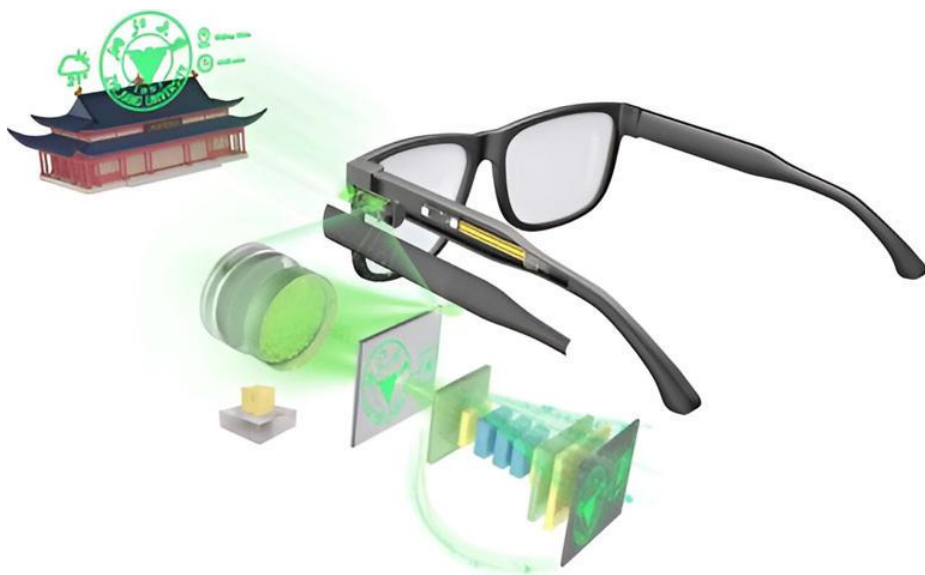
"This ability of extracellular vesicles to transport specific molecular signals to the cell nucleus opens up new perspectives for our understanding of complex cellular interactions in the brain," says Cappello.

According to the authors, these findings underscore the central role of EVs in brain development and could pave the way for new therapeutic approaches for the treatment of neurological diseases in the long term.

More information: Andrea Forero et al, Extracellular vesicle-mediated trafficking of molecular cues during human brain development, *Cell Reports* (2024). DOI: [10.1016/j.celrep.2024.114755](https://doi.org/10.1016/j.celrep.2024.114755)

A new, simpler AR display incorporated into eyeglasses takes an original image (top) and produces a projected image (middle) that is further enhanced by a computer algorithm (bottom). Credit: Adapted from ACS Photonics 2024, DOI: 10.1021/acsphotonics.4c00989

Augmented reality (AR) takes digital images and superimposes them onto real-world views. But AR is more than a new way to play video games; it could transform surgery and self-driving cars. To make the technology easier to integrate into common personal devices, researchers [report](#) in *ACS Photonics* how to combine two optical technologies into a single, high-resolution AR display. In an eyeglasses prototype, the researchers enhanced image quality with a computer algorithm that removed distortions.



Graphical abstract. Credit: ACS Photonics (2024). DOI: 10.1021/acsp Photonics.4c00989

AR systems, like those in bulky goggles and automobile head-up displays, require portable optical components. But shrinking the typical four-lens AR system to the size of eyeglasses or smaller typically lowers the quality of the computer-generated image and reduces the field of view.

Youguang Ma and colleagues may have found a solution for condensing the technology. They combined two optical technologies—a metasurface and a refractive lens—with a microLED screen (containing arrays of tiny green LEDs for projecting images) to create a compact, single-lens hybrid AR design.

Their display's metasurface is an ultrathin, lightweight silicon nitride film etched with a pattern. The pattern shapes and focuses light from the green microLEDs. Then, a black-and-green image forms on a refractive lens made from a synthetic polymer, which refines the image by sharpening and reducing aberrations in the light.

The final image is projected out of the system and superimposed onto an object or screen. To further enhance the resolution of the projected image, Ma and the team used computer algorithms to identify minor imperfections in the optical system and correct them before light leaves the microLED.

The researchers integrated the hybrid AR display into a pair of eyeglasses and tested the prototype's performance with computer image enhancement. Projected images from the one-lens hybrid system had less than 2% distortion across a 30° field of view—image quality that's on par with current commercial

AR platforms with four lenses. The researchers then confirmed that their computer preprocessing algorithm improved a reprojected AR picture of a red panda.

The reprojected red panda was 74.3% structurally similar to the original image—a 4% improvement from the uncorrected projection of the image. With additional development, the researchers say the platform could extend from green to full color and enable a new generation of mainstream AR glasses.

More information: Qikai Chen et al, Hybrid Meta-Optics Enabled Compact Augmented Reality Display with Computational Image Reinforcement, *ACS Photonics* (2024). DOI: [10.1021/acsphotonics.4c00989](https://doi.org/10.1021/acsphotonics.4c00989)

Provided by American Chemical Society



Meta Orion AR Glasses

Mark Zuckerberg has unveiled the Meta Orion AR glasses. Although still a prototype, these holographic [Augmented Reality](#) (AR) glasses offer multi-sensory controls.

Meta's AR glasses offer holographic overlay

At the Meta Connect 2024, Mark Zuckerberg unveiled Meta's holographic AR glasses prototype. Codenamed Orion, the AR glasses are [still a work in progress](#). However, the prototype Mark demoed [was reportedly fully functional](#).

The Meta Orion AR glasses are the culmination of over a decade's work, announced the Meta CEO. As the [brief demo video](#) indicates, these AR glasses appear thick. However, they weigh less than 100 grams.

Meta's latest AR tech offers a virtual overlay to augment what wearers will see in the real world. These glasses can highlight objects, let users video chat with another person's life-like persona, and give wearers access to web browsing and video streaming.

Mark has cautioned that the design of the Meta Orion AR glasses isn't yet finalized. Interestingly, he implied the aesthetics, and not the inner hardware, "aren't as fashionable".

The Orion AR glasses benefit from Meta's Artificial Intelligence LLM. Both the Generative Artificial Intelligence ([Gen AI](#)) and the glasses are multimodal. In other words, they can see and understand whatever the wearer is looking at.

Meta Orion AR glasses specifications and features

According to multiple social media posts, Meta's new AR glasses feature "waveguide" displays. In its current iteration, these glasses have a 70-degree FoV (Field of View).

The frame of the AR glasses is made from a Magnesium alloy for better weight and thermal distribution. The stems of the glasses have molded batteries, speakers, and multiple sensors.

The Meta Orion AR glasses reportedly have seven cameras. Coupled with Meta AI, these glasses can accept commands in multiple ways. Wearers can rely on gesture navigation using their eyes and hands. Alternatively, they can use their voice.

Mark indicated the company's latest gadget also had a neural interface. Specifically speaking, there's a wristband that can detect the wearer's hand swipes and movements.

Meta intends to optimize the hardware, make the form factor smaller, and enhance the sharpness of the visuals. Interestingly, the social media giant also indicated it is working on making the glasses more affordable, presumably while working with Ray-Ban.

The post [Meta announces Orion AR glasses with multi-sensory controls](#) appeared first on [Android Headlines](#).

These noodly appendages have the potential to revolutionize brain recording and neurostimulation. - Image credit: Yasar TB et al., Nature Communications 2024 (CC BY 4.0); modified© IFL Science

A team at ETH Zurich is pushing the boundaries of what can be achieved with neurostimulation and neuronal recording technology thanks to the super-flexible electrode bundles they have developed. Rather than traditional electrodes, which can cause some damage to brain tissue when they are inserted, the fibers can seamlessly integrate into the web of dendritic filaments with no harm done.

Electrodes are a vital part of brain-computer interfaces (BCIs) and deep-brain stimulation (DBS) devices. In DBS, a pacemaker-like component instructs the electrode to deliver bursts of electricity to a region of the brain to help relieve the symptoms of conditions like [Parkinson's disease](#) and [obsessive-compulsive disorder](#). In BCIs, electrode arrays record brain activity that can then be translated by a computer system into, for instance, [speech](#) or movement. Perhaps the most well-known developer of BCIs is Elon Musk's [Neuralink](#).

Neuralink's implant uses a somewhat flexible probe that is an improvement on more rigid, silicon-based probes. Others are working with electrode meshes that are more biocompatible still; but when [Mehmet Fatih Yanik](#), Professor of

Neurotechnology at [ETH Zurich](#), first wanted to experiment with brain recording tech a decade ago, it quickly became clear that a new solution was needed.

I'm always telling my students that one day they may be putting this thing into my brain.

Professor Mehmet Fatih Yanik

Yanik told IFLScience that his lab brings together neuroscientists and engineers who, over time, have "built the technology that we wanted to have". By combining their expertise, the team has now unveiled a brand-new type of electrode: a spaghetti-like bundle of extremely fine gold fibers encapsulated in a polymer. By recapitulating, as closely as possible, the structure of the tissue into which you want to insert the electrode, you can make that insertion as gentle as possible while also maximizing the potential applications of the technology.

"If you think about the neurons themselves, the cell body is about 20 microns, 10 microns," Yanik told IFLScience. "And then you have these dendritic arbors, which are on a few-micron scale. And when you try to [insert] most of these existing technologies today, either silicon or even polymer ones, what happens is you basically are trying to go through a tissue segment, and you have these branches, like tree branches. And what you are doing is you are basically chopping it off."

The spaghetti fibers, by contrast, can integrate into these "tree branches" without causing damage.

So far, so good. But with something so delicate and flexible, perfecting the insertion process took a lot of time: "if you wanted to get into, you know, just a few millimeters below the surface of brain, they just peel off, you know?" Lead author Tansel Baran Yasar, along with colleagues Peter Gombkoto and Wolfger von der Behrens, spent many months on this problem.

The key, it emerged, was inserting the bundles slowly. Postdoctoral researcher Angeliki D. Vavladeli has been continuing to analyze the effects of the insertion on the surrounding brain tissue, and Yanik told us that "it really looks unbelievable."

"The tissue around is very healthy, like starting from the very next neuron there, you know, there's no layer of some junk or anything. It's very beautiful."

For the new study, the team tested four bundles of 64 fibers each in the brains of rats. The electrodes were wired up to a recording device that was attached to the rats' heads, so the animals could move about freely while their brain activity was logged. They demonstrated how neuronal recordings could be performed over long timescales and with good signal quality, as the probes get very close to the nerve cells.

Theoretically, many more than 64 fibers could be included in future iterations, facilitating simultaneous recordings from multiple brain areas and possibly entire brain [networks](#).

"A big, significant effort of our research is right now focused on trying to understand how the brain is representing information [...] and how the different brain areas communicate with each other," Yanik told IFLScience.

Among the many further advances the team is working on right now, under the leadership of Eminhan Ozil they're hoping to engineer the electrode tentacles to include "barcodes" that can tell you precisely which bundle a signal is coming from to a 60-micron resolution – that means "you can tell in the cortex which cortical layer you are [in]." There are also plans to try inserting many more bundles into the brain at once, with the aim of going up to 3,000 separate recording channels – this is currently under development in the lab, headed up by Alexei Vyssotski and Houman Javaheri.

And as well as recording neuronal activity, there's the possibility of using these electrodes as minimally invasive neurostimulators too.

Some time soon, testing will need to move from animal models into humans. A project with collaborators at University College London is already underway, which aims to trial the electrodes as a precision diagnostic tool for people undergoing brain surgery for [epilepsy](#).

Yanik knows that, as one of the research leads, the time may come for him to experience the innovation first-hand, and he's prepped the team accordingly.

"I'm always telling my students that one day they may be putting this thing into my brain," Yanik told IFLScience. "So please make sure it is really nice!"

The study is published in the journal [Nature Communications](#).

How does the brain adapt to different levels of mental challenge? A new neuroimaging study reveals that when we engage in more complex cognitive tasks, our brain activity becomes not only richer in detail but also more streamlined. The findings suggest that the brain adjusts its patterns of activity to match the demands of the task, allowing for more efficient processing during mentally challenging activities.

The study, published in the [Proceedings of the National Academy of Sciences](#), was driven by a desire to understand how the brain manages different cognitive demands. Previous research by the same team had revealed the brain's remarkable ability to reconstruct missing data from minimal measurements, raising questions about why the brain can generate such detailed and efficient activity patterns with limited input.

"Several years ago, my co-author and graduate student at the time, Lucy Owen, and I came out with [a precursor to this study](#), where we found something very surprising," explained study author Jeremy Manning, an associate professor of psychological and brain sciences at Dartmouth College and director of the [Contextual Dynamics Lab](#).

"At the time, we were working with neurosurgical patients who had electrodes implanted in their brains to monitor for seizure activity. A challenge with working with those recordings is that our brains contain roughly a hundred billion neurons, but we can only safely implant around a few hundred wires into someone's brain. So there is a massive undersampling problem: for every measurement we take, we miss roughly a billion others! We wanted to understand how much of that 'missing' data we could reliably and accurately reconstruct using statistical 'hacks.'"

"We were very surprised to find that just a few hundred measurements from an essentially random sampling of locations throughout someone's brain could give us enough information to fill in an accurate guess about activity patterns throughout their entire brain, at millimeter-scale resolutions (roughly on par with the best fMRI available today), but at millisecond-scale sampling rates (roughly 1000 times faster than fMRI)," Manning said. "If human language was similarly

efficient, I'd be able to tell you the details of every Wikipedia article just by speaking a dozen or so words."

"In that initial study, we were primarily concerned with the 'how' and 'what' aspects of our approach: in other words, we reported how we built our model and generated guesses, how we validated the guesses, and the circumstances that affected accuracy, and so on. But it left us with a much deeper question that we weren't able to answer back then: why is it possible to reconstruct what nearly our entire brain is doing at a given moment, using a comparatively miniscule number of measurements? That led us down a rabbit hole of additional questions about the fundamental properties of brain activity patterns. Our findings are reported in this new study."

To answer these deeper questions about how the brain adjusts its activity to match cognitive demands, the researchers examined a dataset collected from previous neuroimaging experiments. These experiments involved functional magnetic resonance imaging (fMRI) scans of participants as they listened to different audio recordings.

Some participants listened to a coherent, seven-minute story, while others listened to a scrambled version of the story, in which either the paragraphs or individual words were randomly ordered. A final group underwent a resting state scan with no auditory stimulus, meant to simulate a condition of minimal cognitive engagement.

The goal was to analyze how the brain's activity changed under these varying levels of cognitive demand. In a high-demand task—following a coherent story—the brain has to actively process and organize information to make sense of the narrative. In contrast, during the scrambled story conditions, the brain's task is less cognitively challenging because the information is less meaningful. The resting state condition provided a baseline measure of brain activity in the absence of any specific cognitive task.

The authors sought to investigate two properties of brain activity: informativeness and compressibility. The authors hypothesized that these properties might shift depending on the complexity of a task, allowing the brain to strike a balance between flexibility and efficiency.

To assess the informativeness and compressibility of brain activity, the researchers used advanced computational techniques. They measured informativeness by analyzing how much specific information about the task was reflected in participants' brain activity. Compressibility, on the other hand, was evaluated by examining how efficiently the brain's activity patterns could be represented using fewer components or data points. A highly compressible brain pattern is one in which fewer pieces of information are needed to reconstruct the full activity.

"In the world of machine learning, the ability to reconstitute a detailed pattern from its parts is called 'compression,'" Manning told PsyPost. "Highly compressible patterns can be accurately rebuilt from just a tiny sliver, like reconstructing the complete text of a novel from just a single word. Another related property is called 'informativeness.' This refers to how 'expressive' a sequence of patterns is— akin to the length of a novel."

The researchers uncovered two key findings. First, brain activity was more informative and compressible when participants engaged in the more demanding task of listening to a coherent story compared to the scrambled story or resting conditions. This suggests that during higher-level cognitive tasks, the brain produces detailed, information-rich activity that is also organized efficiently. In simpler tasks, or during rest, the brain's activity is less organized and contains less specific information.

Second, the study found that these brain patterns became more informative and compressible over time as participants continued to listen to the coherent story. As the narrative unfolded, the brain seemed to adapt by refining and optimizing its activity patterns. This pattern was less pronounced in the scrambled conditions, where the lack of a coherent structure in the story likely led to less mental engagement and, consequently, less organization in the brain's activity.

"Going into this study, we would have guessed that 'compression' and 'informativeness' would have changed in opposite directions," Manning said. "That would be analogous to either being able to reconstruct short novels from just a few words (perhaps under certain cognitive circumstances — representing high compressibility but low informativeness), or being able to reconstruct longer novels from more words (perhaps under different circumstances — representing low compressibility and high informativeness). Finding that compression and

informativeness change in the same direction helped us to understand that these two aspects of how our brains respond can vary independently from each other.”

The researchers also took a closer look at different brain networks to see if certain regions were more affected by task complexity than others. They found that higher-order brain networks, which are typically associated with complex functions like decision-making and memory, showed more pronounced changes in informativeness and compressibility than lower-order networks, which are primarily involved in basic sensory processing. This supports the idea that the brain’s ability to adjust its activity is not uniform across all regions; instead, areas involved in more complex cognitive functions are especially responsive to task demands.

“We have known for a long time that our ‘thoughts’ come from patterns of electrical activity in our brains,” Manning told PsyPost. “What we found is that our brains seem to change the ‘language’ that those patterns are expressed in according to what we are doing. When we are highly engaged or thinking ‘deeply’ about what we are doing, our brains move into a mode where the activity patterns become both highly compressible and highly informative.”

“In other words, our brains start representing what we are doing or thinking about in a very efficient way that is also incredibly robust to data corruption. That helped us understand why, under the right circumstances, it becomes possible to accurately guess what someone’s entire brain is doing from just a few hundred measurements.”

“When we stop being engaged, or when we think more ‘shallowly’ about what we are doing, our brains switch into a much less efficient mode, where the activity patterns become less structured, less informative, and more idiosyncratic,” Manning continued. “We’re not totally sure why this happens, but we go through some speculations in our paper.”

The research provides valuable insights into the fundamental mechanisms of human cognition. But the study, like all research, has limitations. The study only examined a specific set of tasks and stimuli, which means that the results may not apply to all types of mental activities. Additionally, the researchers used one method of measuring brain activity—fMRI—which provides a detailed view of brain activity but is limited by its relatively slow sampling rate compared to other techniques.

"We looked at data from a little over 100 participants, using one set of experimental conditions, and using one method for measuring brain activity," Manning noted. "Although it is tempting to generalize to 'all humans and circumstances,' the true test of these findings, as with any study, will be in how well they replicate and generalize."

The researchers suggest that future studies could examine how the brain's ability to adjust informativeness and compressibility might apply to other cognitive processes, such as decision-making, problem-solving, or creativity. Understanding how these brain properties change in different contexts could offer new insights into the nature of cognition and how the brain adapts to a wide range of mental challenges.

Despite its limitations, the study provides a compelling look at how the brain organizes itself to meet the demands of complex tasks. The findings suggest that the brain's ability to adapt is not just a matter of activating more areas or working harder, but rather involves fine-tuning its activity patterns to balance flexibility and efficiency.

In the long term, this line of research could help scientists better understand how the brain supports higher-level cognitive functions and what happens when these processes break down, such as in conditions like dementia or traumatic brain injury. By identifying the mechanisms that allow the brain to optimize its activity for different tasks, researchers may eventually develop new interventions or treatments to support cognitive health and recovery.

"We are deeply curious about understanding fundamental questions about how our brains work, and what makes us 'us.' This line of work is a tiny part of a much broader literature aimed at uncovering the neural basis of thought," Manning said. "My website is www.context-lab.com. It has links to all of my lab's publications, data, and software, along with some open courses that could be of interest to people who want to learn more about this stuff."

Breathe in, breathe out — new brain scans have revealed that mindfulness meditation really does relieve pain, and not because it acts like a placebo.

Mindfulness meditation refers to the ancient practice of drawing attention to the present moment [in a nonjudgmental way](#) — releasing thoughts of looking silly or doing it wrong, for instance. New research finds that this practice activates specific lines of communication, or pathways between [brain](#) cells, that can reduce the perception of pain.

These pathways differ from those stimulated by the [placebo effect](#), and their activation results in more powerful pain-relieving effects than sham treatments.

These recent findings, published Aug. 29 in the journal [Biological Psychiatry](#), were drawn from healthy people who were exposed to a brief, painful stimulus and then used different methods to alleviate that pain. If the same results show up in patients with [chronic pain](#), mindfulness meditation could be a promising, active therapy option, the study authors argue.

"Millions of people are living with chronic pain every day, and there may be more these people can do to reduce their pain and improve their quality of life than we previously understood," [Fadel Zeidan](#), study co-author and a professor of anesthesiology at the University of California, San Diego, said in a [statement](#).

Mindfulness meditation has been used for millennia in various cultures for [pain-relief purposes](#). However, scientists have questioned whether some of its purported pain-relieving effects actually stem from [the placebo effect](#). This phenomenon causes people to perceive that their symptoms have improved even though they received an inactive treatment that doesn't directly treat their condition.

In the new study, Zeidan and colleagues designed a series of experiments to learn more about how mindfulness meditation affects people's perception of pain.

They recruited 115 healthy volunteers and asked them to undergo one of four interventions. One group undertook guided mindfulness meditation, led by

experienced instructors. Another group participated in a "sham" mindfulness meditation that involved only deep breathing and no cues to tune into their breaths in a nonjudgmental manner. A third group applied a placebo cream — namely, petroleum jelly — to their legs and were told it had pain-relieving effects, while the remaining group just listened to an audio book.

The team did initial training sessions to get people used to the experimental setup and teach the meditation approaches. Then they got down to collecting data using functional magnetic resonance imaging (fMRI), which tracks the flow of blood through the brain to determine which areas are most active at a given time.

Mindfulness meditation influences three pain-related signatures of brain activity: the NAPS (left), SIIPS-1 (center) and NPS (right). A placebo affects only the SIIPS-1, according to the new study. (Image credit: Copyright © the Board of Regents of the University of California)

With the participants' permission, the researchers applied a very hot probe at around 120 degrees Fahrenheit (49 degrees Celsius) to the backs of their legs while they were in the scanner. They scanned the participants' brains before and after the interventions, tracking the changes in activity.

Each time the probe was applied, the participants also rated the pain they experienced on a scale of 0 (meaning "no pain") to 10 (the "worst pain imaginable"). Overall, the researchers found that the group who practiced mindfulness meditation reported significantly greater reductions in pain intensity than those who did the other interventions.

The brain scans uncovered another, perhaps more surprising finding: Mindfulness meditation produced significantly greater reductions in brain activity associated with pain perception and emotional experiences of pain than the other interventions. These patterns of brain activity — respectively known as the [neurologic pain signature](#) (NPS) and the [negative affective pain signature](#) (NAPS) — had been established in prior studies of pain perception.

In other words, the brain scans confirmed what the participants' pain reports had hinted — that mindfulness meditation actively treats pain.

On the other hand, the petroleum jelly only changed the activity of the so-called Stimulus Intensity Independent Pain Signature-1 (SIIPS-1) pathway. Based

on [previous research](#), this pathway is involved in setting our expectations of pain relief from a given treatment. This can then shape how we perceive pain.

This finding suggests that mindfulness meditation engages different parts of the brain than the placebo effect and that it directly turns down brain activity that normally boosts feelings of pain.

These "two brain responses are completely distinct, which supports the use of mindfulness meditation as a direct intervention for chronic pain rather than as a way to engage the placebo effect," Zeidan said.

That said, the short-term pain tested in the study is not directly comparable to chronic pain, so more work will need to be done to confirm meditation's usefulness in that context.

Scientists believe that mutations in the brain they previously thought were rare might actually be happening inside each and every one of us. In fact, scientists believe that these brain mutations could actually be factors in how we age. According to Ryan Mills, a researcher at the University of Michigan, the mutations are not only present, but they're also found in the dorsal lateral prefrontal cortex, an area of the brain that is associated with cognitive ability-and one area typically affected heavily by aging. The mutations in question also appear to be driven by mitochondria.

These brain mutations appear to come from within [our DNA](#) itself, too. The scientists believe that the mitochondria somehow get into the nucleus of our DNA and then get added to our main genome. As I noted above, the mutation was originally assumed to be rare. However, the past few years have provided more data that suggests otherwise.

DNA illustration for data breach

In fact, it could be far less unusual than we thought, especially in cells that are cancerous. Now, Mills and a team of researchers have analyzed even more DNA

samples from brain tissue taken from more than 1200 people during post-mortem examinations. The samples were inspected to see just how the mitochondrial DNA had changed and whether or not it had been added to the nuclear genome.

Mills' team found that not only did the brain mutations occur in far more people than they expected, but they were also far more common-on average, at least-in people who died at younger ages. The researchers aren't sure exactly how closely tied the mutations are to aging. But, Mills says it is "hard for him to believe that the mitochondrial getting into the genome won't have a lasting effect on the human body.

A [study of the researchers' findings](#) has been published in the journal *PLOS Biology*.



Brain implants to restore sight, like Neuralink's Blindsight, face a fundamental problem© PsyPost

Elon Musk [recently pronounced](#) that the next Neuralink project will be a "Blindsight" cortical implant to restore vision: "Resolution will be low at first, like early Nintendo graphics, but ultimately may exceed normal human vision."

Unfortunately, this claim rests on the [fallacy that neurons in the brain are like pixels on a screen](#). It's not surprising that engineers often assume that "more pixels equals better vision." After all, that is how monitors and phone screens work.

In our newly published research, we created a [computational model of human vision](#) to simulate what sort of vision an extremely high-resolution cortical implant might provide. A movie of a cat with a resolution of 45,000 pixels is sharp and clear. A movie generated using a simplified version of a model of 45,000 cortical electrodes, each of which stimulates a single neuron, still has a recognizable cat but most of the details of the scene are lost.

The reason why the movie generated by electrodes is so blurry is because neurons in the human visual cortex do not represent tiny dots or pixels. Instead, each neuron has a particular [receptive field](#), which is the location and pattern a visual stimulus must have in order to make that neuron fire. Electrically stimulating a single neuron produces a blob whose appearance is determined by that neuron's receptive field. The tiniest electrode – one that stimulates a single neuron – will produce a blob that is roughly the size of your pinkie's width held at arm's length.

Consider what happens when you look at a single star in the night sky. Each point in space is represented by many thousands of neurons with overlapping receptive fields. A tiny spot of light, such as a star, results in a complex pattern of firing across all these neurons.

To generate the visual experience of seeing a single star with cortical stimulation, you would need to reproduce a pattern of neural responses that is similar to the pattern that would be produced by natural vision.

In order to do this, you would obviously need thousands of electrodes. But you would also need to replicate the correct pattern of neuronal responses, which requires knowing every neuron's receptive field. Our simulations show that knowing the location of each neuron's receptive field in space is not enough – if you don't also know the orientation and size of each receptive field, then the star becomes a fuzzy mess.

So, even a single star – a single, bright pixel – generates an immensely complex neural response in the visual cortex. Imagine the even more complex pattern of cortical stimulation needed to accurately reproduce natural vision.

Some scientists have suggested that by stimulating exactly the [right combination of electrodes](#), it would be possible to [produce natural vision](#). Unfortunately, no one has yet suggested a sensible way to determine the receptive field of each

individual neuron in a specific blind patient. Without that information, there is no way to see the stars. Vision from cortical implants will remain grainy and imperfect, regardless of the number of electrodes.

Sight restoration is not simply an engineering problem. Predicting what kind of vision a device will provide requires knowing how the [technology interfaces with the complexities of the human brain](#).

How we created our virtual patients

In our work as [computational neuroscientists](#), we develop simulations that predict the perceptual experience of patients seeking to restore their sight.

We have previously created a model to predict the [perceptual experience of patients with a retinal implant](#). To create a virtual patient to predict what cortical implant patients would see, we simulated the neurophysiological architecture of the area of the brain involved in the [first stage of visual processing](#). Our model approximates how receptive fields increase in size from central to peripheral vision and the fact that every neuron has a unique receptive field.

[Our model successfully predicted](#) data describing the perceptual experience of participants across a wide range of studies on cortical stimulation in people. Having confirmed that our model could predict existing data, we used it to make predictions about the quality of vision that possible future cortical implants might produce.

Models like ours are an example of [virtual prototyping](#), which involves using computer systems to improve product design. These models can facilitate new technology development and evaluate device performance. Our study shows they can also offer more realistic expectations about what kind of vision bionic eyes might provide.

First do no harm

In our almost 20 years researching bionic eyes, we've seen the complexity of the human brain defeat company after company. [Patients pay the cost](#) when these devices fail, left stranded with orphaned technologies in their eye or brain.

The Food and Drug Administration could mandate that sight recovery tech companies must develop [failure plans that minimize harm](#) to patients when technologies stop working. Possibilities include requiring companies implanting neuroelectronic devices into patients to participate in [technology escrow agreements](#) and carry insurance to ensure continuing [medical care](#) and [technology support](#) if they go bankrupt.

If cortical implants can achieve anything close to the resolution of our simulations, that would still be an accomplishment worth celebrating. Grainy and imperfect vision would be life-changing for many thousands of people who currently suffer from incurable blindness. But this is a moment for cautious rather than blind optimism.

The image shows corticospinal neurons in a mouse brain. Credit: Philipp Abe and Advanced Lightsheet Imaging Center Campus Biotech

A UNIGE team has discovered the genetic programs that allow motor neurons to retract from the spinal cord. This discovery opens up prospects for combating neurodegeneration.

The motor cortex is made up of neurons responsible for muscle contraction. These neurons have cellular extensions called axons, which project from the cortex into the spinal cord. During brain development, some of these neurons retract their axons to project, not into the spinal cord, but into the brain. How does this happen?

Neuroscientists at the University of Geneva (UNIGE) have discovered that everything is linked to genetic programming. Indeed, our genes define which parts of the cortex are dedicated to motor functions and which are not, by directing neuronal projections. This fundamental discovery, [published](#) in the journal *Nature*, opens up new avenues for countering motor disorders.

The cerebral cortex is the outer part of the brain responsible for higher cognitive functions, such as thinking, perception, decision-making, language and memory. It also processes sensory information and controls movement.

To do this, it dedicates part of its volume to movement: the motor cortex. This is where the neurons responsible for muscle contraction—the corticospinal neurons—project to the spinal cord. Despite the compartmentalization of the cortex, corticospinal neurons are found outside the motor cortex. Why is this?

Selection during development

To answer this question, the neuroscientists focused on the mouse. "The technologies currently available do not allow us to address these questions in humans. Corticospinal neurons are highly conserved across species and can therefore be studied in rodents," says Denis Jabaudon, full professor in the Department of Basic Neuroscience at the UNIGE Faculty of Medicine and initiator of the study.

Using approaches that make brain tissue transparent and allow specific staining of neuron subtypes, the research team first studied the evolution of corticospinal projections during brain development. "We have thus confirmed a fascinating observation made several decades ago, but little known to neuroscientists," explains Jabaudon.

At the start of brain development, neurons in the cortex project into the spinal cord. Those that will form the future motor cortex remain there, while those that will make up the rest of the cortex gradually retract. In the end, in an adult brain, some corticospinal neurons can act as far away as the spinal cord, and others with a shallower range of action, which remain in the brain itself.

A dedicated genetic program

Jabaudon's team then compared the genes expressed by these two types of neurons and identified a family of genes responsible for their ability to retract.

"Without them, these neurons would remain anchored in the spinal cord during development, and our cortex would probably be deprived of its higher cognitive functions," adds Jabaudon.

To demonstrate the importance of this genetic program, the researchers focused on three genes and, using gene-editing techniques—CRISPR-Cas9—were able to modulate their expression in neurons with projections into the spinal cord.

"This was a major technical challenge and represents a new way of assessing the influence of a set of genes on cellular mechanisms," says Jabaudon. It was thus possible to force the retraction of neurons from the spinal cord into the brain.

An essential discovery

"Understanding how corticospinal neurons emerge during development and how they project into our central nervous system is important, as they are essential for fine motor skills. However, they are highly sensitive to spinal cord injury or to the consequences of amyotrophic lateral sclerosis, a disease that causes a progressive paralysis of muscles," says Jabaudon.

"In this study, we succeeded in forcing the neurons to retract. But everything suggests that the opposite could also be done, which opens up fascinating possibilities," he adds. The research team is now considering reprogramming neural cells in other contexts, such as neurodegenerative diseases.

More information: Philipp Abe et al, Molecular programs guiding arealization of descending cortical pathways, *Nature* (2024). DOI: [10.1038/s41586-024-07895-y](https://doi.org/10.1038/s41586-024-07895-y)

Provided by University of Geneva

Ever since I have come to understand I am neurodivergent, more of the world has opened up to me. I now understand why I found certain environments so difficult, why some people have become inexplicably annoyed by me, and why I might respond to people in ways they don't expect.

Finding neurodivergent communities online, particularly on X (formally known as Twitter) was immensely supportive. I saw others talk about their own challenges and I was often able to relate. A common topic was how the world does not appear designed for the neurodivergent, with the workplace as the number one offender. This constant pain in dealing with the public world is why the neurodivergent movement has thrived.

The neurodivergent movement has gained traction, in part, because the prefix *neuro* has the habit of making anything sound legitimate. *Neuro* is always contemporary regardless of the year, makes people pay attention, and carries with it the command of being taken seriously, something those with autism crave.

A major benefit to neurodivergent culture is that it helps to raise questions over identification. It encourages those with autistic traits to interact with others and discuss similar experiences, which enables them to better understand themselves. This is not dissimilar to coming out of the closet with a growing sense of private understanding and a drive to interact publicly with an accepting community.

The trouble is *neurodivergent* lacks a solid foundation and appears arbitrary. The term lacks a literal meaning, other than to imply that different neural arrangements lead to different types of people. There are 8 billion people on Earth, each with a brain made up of billions of neurons with trillions of synaptic connections that are constantly changing throughout the expanse of the person's life; moment to moment, person to person, divergency *is* the norm.

Neurodivergent people are divergent from other neurodivergent people. Neurotypical people are divergent from other neurotypical people. A dog is neurodivergent from a cat. I am neurodivergent to the me of ten years ago, even ten seconds ago. And if the criteria for acceptance into neurodivergent is to merit neurological difference from a *normal*, then it must also be accepted that psychopaths and pedophiles are neurodivergent.

The term *neurotypical* is frequently used to describe the *other*. The term provides a target with which to level criticism against. This is not dissimilar to *homophobe* or *racist* or *misogynist*. When seeking measures of equality and acceptance, it is crucial to have a label for people that are the problem. Names for the oppressor help to ease cohesion, prevent in-fighting, build enthusiasm, and drive momentum forward, picking up social and political capital. These are all good things and would not be necessary if everyone was receiving the respect and understanding they deserve.

The downside is that the *other* is caricatured and subject to picking up as many stereotypes as the person seeking equality. Perhaps even without intention, an us-vs-them mentality is established, which questions the likelihood of future integration. Unlike white on black racism, neurotypicals are not actively seeking to oppress the neurodivergent; the major problems appear to be ignorance and stigmas and an unwillingness to change the status quo. Neurotypicals, for the most part, do not identify as *neurotypical*, which undermines the movement because as far as the rest of the world is concerned, neurotypicals do not exist.

This is not the first time the prefix *neuro* has been co-opted to re-brand academic subjects or promote business. Technological advancement at the end of the 90s saw fMRI become a popular method for understanding the brain. Thoughts that a participant had while being scanned could be tentatively linked with specific areas of the brain. This caused great excitement and resulted in the prefix *neuro* being added to many traditional areas of study to boost interest. Fortunately, the limitations of fMRI are now widely known and even though this was a movement of sorts, the focus had not drifted too far from discussions of neurons. The *neuro* in neurodivergent appears mostly untethered.

At some point, all activism must lead to a pragmatic assimilation into the status quo. In order for this to happen an unambiguous and broadly accepted terminology must be present. *Autism*, *ADHD*, and other personalities need to be seen as normal and human, and thus inclusion is necessary and obvious.

The bitter truth behind the good intentions of a diagnosis, something which is done to facilitate treatment or therapy, becomes an event in history that forever tethers the patient from personal growth and in some cases, relationships. During the diagnosis, the person is deemed to be *in need of care*, after all, they are now

the *patient*. But even after many years of good therapeutic habits, the person is still considered to be in need of care and liable to others – a liability.

A diagnosis also implies a deviation from *healthy* or *normal* and will become a defining feature of the medical record, which will always make other people question if the person is healthy or normal in the present. A mental health diagnosis can become a sinister stigma, because there will always be doubt over whether the person is normal or healthy – in some cases preventing relationships before they can even start.

Many of those diagnosed with autism, ADHD, bipolar disorder, Tourette's Syndrome, etc. could be forced to deal with these problems and have to work hard and struggle to be treated as an independent, autonomous person. The neurodivergent movement has partly been successful because *neurodivergent* is not a term of diagnosis, but a voluntary label that hinges on the fact that difference is not disorder.

Some of the terms used to define the traits within autism diagnosis, under other circumstances, might simply be seen as eccentric. Terms like *disturbances*, *difficulties*, *rituals*, *deficits*, *hypo-*, *hyper-*, etc. The definition of *normality* appears to have been randomly decided and anything that deviates from this definition is therefore *abnormal*. An autist would be well within their rights to reverse the view of these traits and determine that it is the allist who needs the diagnosis.

Many autists do struggle in a world that has been determined and structured by allists, particularly in educational and work settings. Theoretically, if these environments can be re-structured and re-determined so that an autist can flourish, the ease with which they interact with this environment would mean anybody observing would think everything was normal. This means that those who control the environment control what is normal.

The diagnostic behavioral traits are also an issue. Usually, if somebody demonstrates a high enough frequency of a particular trait, they will have a high score and that score will become the determination of a diagnosis. In a world of traits and spectrums, it is likely that many allists will also share autistic traits, such as being comfortable with routine, or a level of fatigue when it comes to prolonged eye contact, or having a somewhat obsessive private interest (in allistic speak, these would be hobbies and pastimes).

That fact that allists can have autistic traits suggests that if social and civil changes were made to benefit somebody with autism, they would also benefit the allist. In addition, because allists and autists can share traits commonly associated with each other, taken together it could just be representative of the traits that make people human.

Many autists have to find and train different behaviors that allows them to mask and deal with being out in the workplace with other people, but this is not synonymous to those with autism as all workers have to find ways to manage long days and increased productivity in difficult environments. Often, workplaces are thought of as normal and the ability for an employee to advance has more to do with a willingness to endure. But this demonstrated struggle is not necessarily useful and if workers could have power over how they get the job done, morale would be higher and productivity would be maximized.

Making changes for those who are neurodivergent would also create an environment where all can be happy. Having less meetings and time for people to decompress on their own would help all workers, as work that is done in solitude is just as important as necessary meetings.

An environment that recognizes diversity would dissolve the need for the term *neurodiversity*. But what about *normality*?

In behavioral science, normality appears defined as the absence of the characteristic being studied. Behavioral research experiments typically recruit at least two groups of people; one group that has been screened to ensure they show behavioral traits of the abnormality being studied, and another group that does not display these traits – the control group. Any number of tests can then be given to all groups and any differences that appear based upon group identity can be verified statistically and the difference published as a *finding*.

However, it is worth noting that there are no studies determining normality in mental health, after all, in a field that struggles with resource and funding, what would any research team have to gain by pursuing a credible diagnosis for *normality*? This means that normality is not scientifically verified and is made all the more impossible to pursue by the ever changing nature of a person's mental health.

Yet, for such a cherished moniker of considering oneself *normal*, is it good enough to define it simply by the traits/dysfunctions/disorders that you do not have? It appears to be a travesty of thought to make an observation of somebody displaying *difference* to you and declaring that you are normal because you are not *that*. How satisfied would we be in situations where we needed to learn about another person, in knowing simply what they are not?

How do you determine a person's *substance* by the *absence* of traits?

Lennard J. Davis notes in 'The Disability Studies Reader' (4th Ed.) that the terms *norm* and *average* only entered European languages in the 19th Century. Their arrival coincided with ideas that were being used in the field of statistics. What had been applied in the mathematical determination of astronomical events bled over into the study of human characteristics, such as height and weight. However in this natural accretion, unguided and subject to nineteenth century prejudices, the search for normal behaviors quickly became marred by the assumptions of the privileged.

Statistics is a powerful tool and can be used with great effect to convince scientists of the objectivity of research, but they are only as powerful as their interpretation. Statistics can demonstrate difference like nothing else, but the basis of comparison is loaded with assumptions of deviance versus absence of deviance. When it comes to understanding something as precious as humanity, is that good enough for us? Every single study should have a rigorous definition of what has been considered normal in light of the research question. *Normal* is needed for statistics to work.

Normality seems to be everything about humanity that we do not consider different or deviant, yet when pressed would struggle to define. This leads one to ask, "Is normality more of a *feeling* than a state of being?" Normality appears to have a lot in common with the mathematical concept of *zero*. Both concepts trick us into thinking they are well defined when it is in fact the opposite. The infinity of the absence tricks us into thinking there is substance.

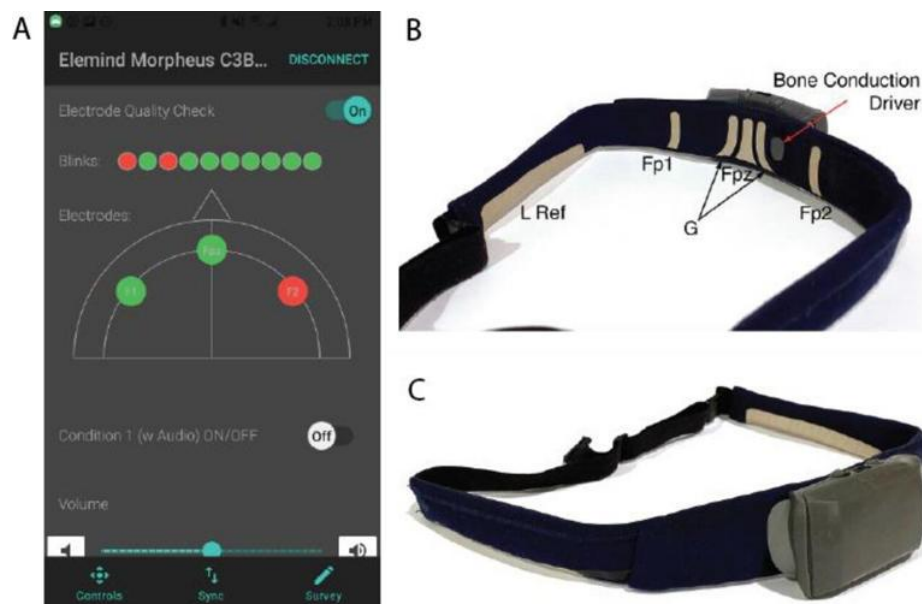
In a world of scientifically and medically confirmed diagnoses, the definition of a normal person is one who would without fail qualify for the control group in any research (unless their socioeconomic markers do not match). Normality is a permanent membership in the control group for every possible behavioral experiment, yet this is clearly impossible, and even *inhuman*.

In a world where those who have been deemed different are having to fight for more inclusion and equal rights, conversations around normality matter.

If only there was a condition called *Manifestly Normal Disorder*, a list of symptoms to define *normal* would have to be rigorously defined in order to screen for the experimental group.

It is worth reminding ourselves that the middle of the bell curve is not where to find normal. Normal is *the* bell curve.

Jack Pemmet is a medical and science writer and has published academically on psychopathy and personality disorders. His work has been published in the *Seattle Times*, *Sheffield Star*, and *Psychology Today*.



The Elemind Neuromodulation device (ENMod). (A) The primary UI of the smartphone app used to control the device. Users were given information about electrode contact using an eyeblink test and real-time signal quality of each frontal electrode. (B) Back view showing the left over-the-ear reference electrode (L Ref), recording electrodes Fp1, Fpz, and Fp2, ground electrode "G", and the bone conduction driver. (C) Front 3/4 view of the detachable processor unit attached to the fabric headband. Left over-the-ear reference electrode shown. Credit: Scientific Reports (2024). DOI: 10.1038/s41598-024-63385-1

Do you ever toss and turn in bed after a long day, wishing you could just program your brain to turn off and get some sleep? That may sound like science fiction, but that's the goal of the startup Elemind, which is using an

electroencephalogram (EEG) headband that emits acoustic stimulation aligned with people's brainwaves to move them into a sleep state more quickly.

Published in *Scientific Reports*, a [small study](#) of adults with sleep onset insomnia, 30 minutes of stimulation from the device decreased the time it took them to fall asleep by 10 to 15 minutes. This summer, Elemind began shipping its product to a small group of users as part of an early pilot program.

The company, which was founded by MIT Professor Ed Boyden '99, MNG '99; David Wang '05, SM '10, Ph.D. '15; former postdoc Nir Grossman; former Media Lab research affiliate Heather Read; and Meredith Perry, plans to collect feedback from early users before making the device more widely available.

Elemind's team believes their device offers several advantages over sleeping pills that can cause side effects and addiction.

"We wanted to create a nonchemical option for people who wanted to get great sleep without side effects, so you could get all the benefits of natural sleep without the risks," says Perry, Elemind's CEO.

"There's a number of people that we think would benefit from this device, whether you're a breastfeeding mom that might not want to take a sleep drug, somebody traveling across time zones that wants to fight jet lag, or someone that simply wants to improve your next-day performance and feel like you have more control over your sleep."

From research to product

Wang's academic journey at MIT spanned nearly 15 years, during which he earned four degrees, culminating in a Ph.D. in artificial intelligence in 2015. In 2014, Wang was co-teaching a class with Grossman when they began working together to noninvasively measure real-time biological oscillations in the brain and body.

Through that work, they became fascinated with a technique for modulating the brain known as phase-locked stimulation, which uses precisely timed visual, physical, or auditory stimulation that lines up with brain activity.

"You're measuring some kind of changing variable, and then you want to change your stimulus in real time in response to that variable," explains Boyden, who pointed Wang and Grossman to a set of mathematical techniques that became some of the core intellectual property of Elemind.

Phase-locked stimulation has been used in conjunction with electrodes implanted in the brain to disrupt seizures and tremors for years. But in 2021, Wang, Grossman, Boyden, and their collaborators published [a paper](#) showing they could use electrical stimulation from outside the skull to suppress essential tremor syndrome, the most common adult movement disorder.

The results were promising, but the founders decided to start by proving their approach worked in a less regulated space: sleep. They developed a system to deliver auditory pulses timed to promote or suppress alpha oscillations in the brain, which are elevated in insomnia.

That kicked off a years-long product development process that led to the headband device Elemind uses today. The headband measures brainwaves through EEG and feeds the results into Elemind's proprietary algorithms, which are used to dynamically generate audio through a bone conduction driver. The moment the device detects that someone is asleep, the audio is slowly tapered out.

"We have a theory that the sound that we play triggers an auditory-evoked response in the brain," Wang says. "That means we get your auditory cortex to basically release this voltage burst that sweeps across your brain and interferes with other regions."

"Some people who have worn Elemind call it a brain jammer. For folks that ruminate a lot before they go to sleep, their brains are actively running. This encourages their brain to quiet down."

Beyond sleep

Elemind has established a collaboration with eight universities that allows researchers to explore the effectiveness of the company's approach in a range of

use cases, from tremors to memory formation, Alzheimer's progression, and more.

"We're not only developing this product, but also advancing the field of neuroscience by collecting high-resolution data to hopefully also help others conduct new research," Wang says.

The collaborations have led to some exciting results. Researchers at McGill University found that using Elemind's acoustic stimulation during sleep increased activity in areas of the cortex related to motor function and improved healthy adults' performance in memory tasks. Other studies have shown the approach can be used to reduce essential tremors in patients and enhance sedation recovery.

Elemind is focused on its sleep application for now, but the company plans to develop other solutions, from medical interventions to memory and focus augmentation, as the science evolves.

"The vision is how do we move beyond sleep into what could ultimately become like an app store for the brain, where you can download a brain state like you download an app?" Perry says. "How can we make this a tool that can be applied to a bunch of different applications with a single piece of hardware that has a lot of different stimulation protocols?"

More information: C Scott Bressler et al, A randomized controlled trial of alpha phase-locked auditory stimulation to treat symptoms of sleep onset insomnia, *Scientific Reports* (2024). DOI: [10.1038/s41598-024-63385-1](https://doi.org/10.1038/s41598-024-63385-1)

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Provided by Massachusetts Institute of Technology

Scientists in the UK have manipulated two prominent types of brain wave while volunteers slept, in an effort to develop better tools to study critical neurological activities.

The waves, referred to as alpha and theta oscillations, are strongly associated with resting and relaxing states, including the [Rapid Eye Movement](#) (REM) stage of unconsciousness.

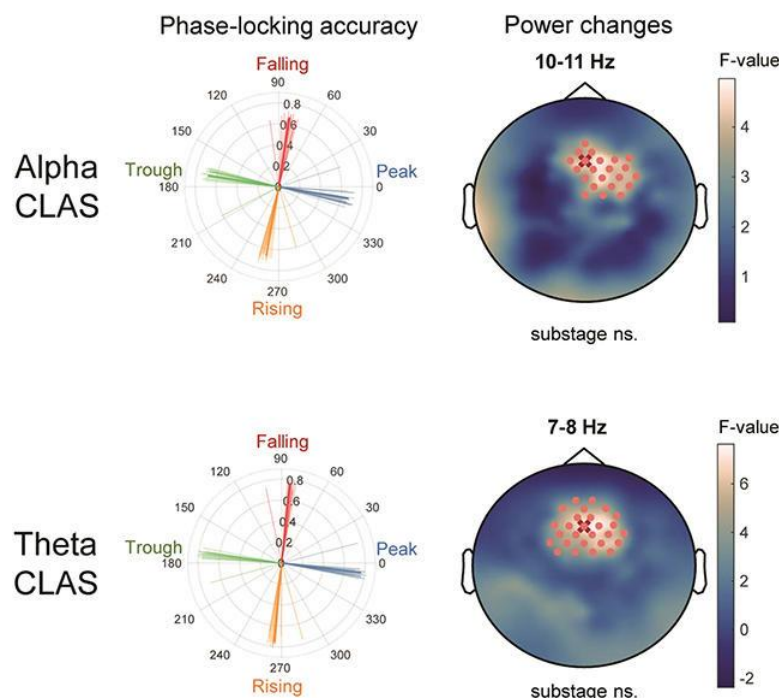
Named for the jerking motion of our eyes while in this stage of sleep, REM coincides with the appearance of our most [vivid dreams](#). The stage is also considered to play an important role in [memory consolidation](#) and honing cognition, making any brain wave activity an attractive target for scientists.

"Brain oscillations assist in the working of the brain and how it learns and retains information," [says](#) neuroscientist Valeria Jaramillo, from the University of Surrey.

"Brain oscillations during REM sleep have been implicated in memory functions – however, their exact role remains largely unclear."

A process called closed-loop auditory stimulation (CLAS) [has been successfully used](#) to enhance or disrupt brain waves in non-REM sleep, precisely targeting the ebb and flow of brain waves via sounds delivered through headphones.

The process had rarely been applied to sleepers outside of this state, so researchers from the University of Surrey tested the method on volunteers to determine if it might also apply to waves produced during REM.



Sounds were used to target different types of oscillations. (Jaramillo et al., SLEEP, 2024)

In tests involving 18 participants, the researchers changed both the speed and strength of the brain waves as measured through electrodes on the skull.

Alpha (around 8 to 12 Hertz) and theta (around 4 to 8 Hertz) oscillations typically flow through the brain's frontal region while we're in a relaxed state, such as when we're dozing or deciding whether to get out of bed to start the day.

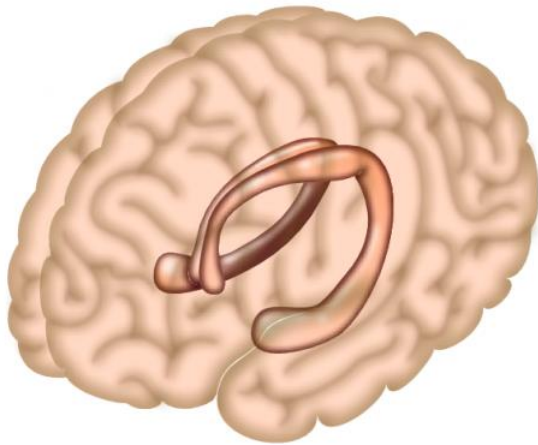
In fact, these brain waves are pretty similar whether we're awake or in REM sleep. We know that brain waves, pulses of electrical activity triggered by neurons, help [in the healthy functioning](#) of the brain. If we can control them to an extent, that's potentially helpful in making sure the brain is working as it should – and in slowing the rate of degeneration associated with dementia.

"Using sound stimulation to change brain oscillations whilst a person sleeps shows therapeutic promise," [says](#) University of Surrey neuroscientist Ines Violante.

"There is currently no cure for dementia, only medication that can slow down disease progression or temporarily help a person with their symptoms, so it is important that we think innovatively to develop new treatment options."

A lot more research will be needed to show this can actually have a therapeutic effect on dementia, but [scientists have already shown](#) that the symptoms of dementia – trouble with memory and cognitive abilities – often coincide with the slowing of brain wave oscillations, which is something we might now be able to influence.

"This could pave the way for a new approach on how to treat patients with dementia, as the technique is non-invasive and undertaken whilst they are asleep, lessening the disruption to their lives and enabling us to be more targeted in our approach," [says](#) Derk-Jan Dijk, a professor of sleep and physiology at the University of Surrey.



The hippocampus is a region of the brain largely responsible for memory formation. Credit: Salk Institute

Researchers at the University of Birmingham have uncovered a surprising role of the hippocampus—linking this part of the brain to the control of skilled actions such as handwriting, typing, and playing music.

The hippocampus is traditionally associated with memory for events and spatial navigation, but a new study challenges these long-held distinctions and opens new possibilities for rehabilitation of neurological and neurodegenerative disorders that affect movement.

Publishing [their findings](#) in *The Journal of Neuroscience*, the research team reveal evidence suggesting that the hippocampus plays a role in retrieving and organizing flexible movement sequences from memory.

The research team reanalyzed functional MRI (fMRI) data to focus on brain activity in key subcortical regions as participants performed well-practiced finger sequences from memory on a force-sensitive keyboard, resembling piano playing.

While motor areas in the basal ganglia and the cerebellum—typically associated with the development of "muscle memory" for learned motor skills—showed increased activity during the sequence task, the study uncovered that it was the hippocampus, rather than these motor areas, that held information about the

finger order of the sequence a participant was about to perform. This is like predicting whether a person would type "fears" or "fares" from the activity in the hippocampus alone.

Associate Professor and senior author of the study, Dr. Katja Kornysheva, from the University of Birmingham, commented, "This result is interesting because it shows that the brain systems for episodic and procedural memory work together more than we thought. This is especially true when we need to remain flexible and switch between learned sequences, for example, when typing on a computer keyboard or playing music with others."

Dr. Rhys Yewbrey, a former doctoral student in Kornysheva's research group and first author of the study added, "Our research suggests that the hippocampus may be important in skilled and flexible motor control, for setting up a course plan of action. This knowledge could help develop more effective training programs for neurological rehabilitation of actions, as well as for speeding up the acquisition of new skills."

The researchers hope their findings will encourage further exploration into the interaction between memory systems and inspire novel therapies that can enhance both motor function and cognitive health.

More information: Rhys Yewbrey et al, The hippocampus pre-orders movements for skilled action sequences, *The Journal of Neuroscience* (2024). DOI: [10.1523/JNEUROSCI.0832-24.2024](https://doi.org/10.1523/JNEUROSCI.0832-24.2024)

Provided by University of Birmingham

As a rat plans to move from a start position to a target, it can consider the location of the target in "world" coordinates (shown as the target in relation to the reward port with blue vectors) or in "self" coordinates (shown as the target in relation to the current position of the rat at the start port, with green vectors). Researchers found that the self-centered representation dominated during the planning period. Credit: Sainsbury Wellcome Centre

In the brain's secondary motor cortex, researchers have discovered two distinct maps that play a crucial role in spatial planning and navigation. The research, led by Dr. Jeffrey Erlich, Group Leader at the Sainsbury Wellcome Centre at UCL, provides a new approach to studying spatial planning in rodents, and could have

implications for understanding neurological conditions that affect spatial attention, such as stroke.

"We discovered that the premotor cortex uses a self-centered coordinate system for spatial planning, but that it also encodes a world-centered map that is used for determining the body's current position in the world. This self-centered and world-centered information is combined in individual neurons in a multiplicative way, which makes it easier to disentangle downstream," explained Dr. Erlich, corresponding author on the study.

The study, [published](#) in the *Journal of Neuroscience*, outlines how the researchers designed a novel task in rats that allowed them to differentiate between self-centered and world-centered reference frames. They recorded neural activity from an area of the brain known as the frontal orienting field (FOF) in the secondary motor cortex in rats and used machine learning techniques to decode the information.

"Imagine being asked where the nearest coffee shop is. You could say 'walk forward and turn left' (self-centered directions) or 'walk north, then east' (world-centered directions). We want to understand how the brain transitions between these reference frames and transforms them into action," explained Dr. Erlich.

The researchers developed a task involving a wall with seven portholes. Rats were trained to place their nose into a starting porthole, after which a light would appear in another porthole, designating it as the target. The rats then had to wait for an auditory cue before moving their nose to the target porthole to receive a reward. This waiting period allowed the researchers to distinguish between planning and action in the brain.

"By adding the right amount of complexity to our task, we were able to have good experimental control over the timings. This approach allowed us to tease apart the different dimensions of representation," explained Dr. Erlich.

Some trials had different movement directions that led to the same target, and some had the same movement direction but led to different targets as they had different starting points. The researchers examined the neural activity during the period in between the visual and auditory cues, to establish whether the brain was planning based on the direction or final position, thereby determining if the FOF was using a self-centered or world-centered map.

"We were surprised to find a world-centered map in FOF as this has never been reported before. We want to explore what this position information is being used for and under what circumstances it becomes functionally relevant," concluded Dr. Erlich.

The team is now exploring how these dual maps are used in tasks where the instructions are given in world-centered coordinates. They are also studying how the brain plans more complex sequences of movements. The ultimate goal of this research is to further understand the fundamental principles of spatial attention and how attention is linked to planning and execution of orienting movements. This has potential implications for neurological conditions such as hemispatial neglect following a stroke, where people cannot process or shift attention to one part of the world.

More information: Liujunli Li et al, Encoding of 2D Self-Centered Plans and World-Centered Positions in the Rat Frontal Orienting Field, *The Journal of Neuroscience* (2024). DOI: [10.1523/JNEUROSCI.0018-24.2024](https://doi.org/10.1523/JNEUROSCI.0018-24.2024)

A fluorescence micrograph of a CA1 in a mouse's hippocampus. RIKEN researchers silenced the pyramidal cells in this region. Credit: Adapted from Nature Communications (2024). DOI: 10.1038/s41467-024-46478-3

RIKEN neuroscientists have gained new insights into how the hippocampus generates and sustains oscillations, which will be helpful for informing models on how the brain region works.

Thomas McHugh of the RIKEN Center for Brain Science has devoted most of his career to studying a single brain region—the hippocampus. One of the most studied regions in the mammalian brain, the hippocampus manages episodic memories and spatial navigation among other things. You use it when recounting events and locating your car in a parking lot.

"If you damage your hippocampus, you will lose the ability to form episodic memories, while retaining other kinds of memories such as motor memory," explains McHugh. "That means, for example, you could still get better at tennis, but you won't ever remember practicing."

While the hippocampus has been much studied, many aspects of it remain mysterious. For example, waves of different frequencies flow through it, which perform different but overlapping functions. These oscillations are set up and sustained by precise timing of excitations and inhibitions, which are controlled by a delicate feedback mechanism. But to date no one has successfully modeled this process.

There are three such oscillations in the CA1 region of the hippocampus—a region towards the back end in terms of processing sensory input. Ripples are the fastest of these oscillations, with about 100 to 300 ripple oscillations per second.

Now, McHugh and co-workers have conducted a try-it-and-see experiment to discover what would happen if they turned off the output from pyramidal cells in the CA1 of mice by using a genetics approach. Their results are [published](#) in the journal *Nature Communications*.

"We didn't have a strong hypothesis," recalls McHugh. "We knew things might look strange, but we didn't really know what to expect."

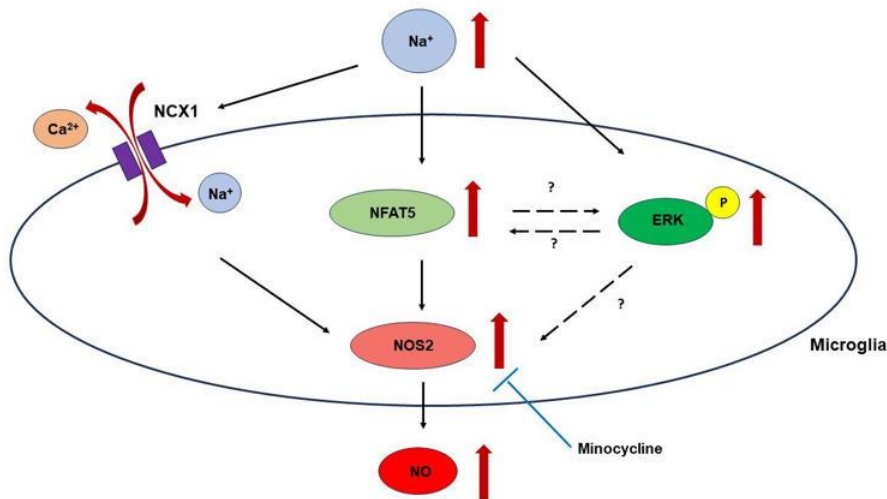
While the mice behaved similarly to normal mice, the thing that really stood out was the activity of their ripples. "Even when we were collecting the first data, it was obvious the ripples were very different—they were way larger and faster," says McHugh. "It looked almost epileptic; there was this crazy activity all the time."

McHugh suspects that this is because the CA1 pyramidal cells play an inhibitory role in regulating oscillations, and when this was turned off the oscillations went out of control.

"It's like if you're teaching a classroom and all the kids are screaming. If you're trying to hear what one kid's saying, you yell 'Shut up!' and let that kid talk," says McHugh. "And so these neurons in the CA1 are basically telling all their neighbors to shut up through this inhibitory system."

This finding will be invaluable for developing better models for the processing going on in the hippocampus.

More information: Chinnakkaruppan Adaikkan et al, Silencing CA1 pyramidal cells output reveals the role of feedback inhibition in hippocampal oscillations, *Nature Communications* (2024). DOI: [10.1038/s41467-024-46478-3](https://doi.org/10.1038/s41467-024-46478-3)



A study by researchers from Fujita University reveals that hypernatremia enhances NFAT5 and NO production in microglia and minocycline mitigates this response. The image above is a schematic showing the effects of hypernatremia on microglia. Credit: Peptides (2024). DOI: [10.1016/j.peptides.2024.171267](https://doi.org/10.1016/j.peptides.2024.171267)

Microglia are the brain's immune cells known to play a vital role in maintaining neural function and responding to potential threats. However, when the brain is subjected to hyperosmotic stress—a condition characterized by elevated extracellular sodium levels, the microglial response can become exaggerated, leading to potentially harmful effects. Understanding the mechanisms behind this heightened response is crucial for the treatment of hypernatremia-induced neurological dysfunctions.

To address this issue, a research team led by Professor Yoshihisa Sugimura from the Department of Endocrinology, Diabetes, and Metabolism at Fujita Health University, Japan explored the effects of hyperosmotic stress on microglial cells. The study was co-authored by Sachiho Fuse, Haruki Fujisawa, and Atsushi Suzuki from the same department and the findings were published in the journal *Peptides* on June 20, 2024.

In this study, the researchers focused on the role of NFAT5, a transcription factor known for regulating cellular responses to osmotic stress. Despite NFAT5's well-established role in other cell types, its function in microglia was not well understood. Hence, the researchers aimed to determine whether NFAT5 influences the expression of NOS2, an enzyme involved in NO production, under hyperosmotic conditions. Additionally, the researchers evaluated the potential therapeutic effects of minocycline, an anti-inflammatory drug, on microglial responses to hyperosmotic stress.

First, the researchers subjected the BV-2 microglial cells to hyperosmotic stress by increasing extracellular sodium concentrations by 20 and 40 mM above normal levels. They measured changes in NFAT5 expression, NOS2 expression, and NO production. Additionally, they explored the role of the $\text{Na}^+/\text{Ca}^{2+}$ exchanger, NCX in this process and investigated the effects of minocycline.

Elaborating on the findings, Prof. Sugimura says, "The results revealed that acute and chronic hyperosmotic stress significantly increased NFAT5 expression in BV-2 microglial cells. This upregulation of NFAT5 was associated with enhanced NOS2 expression and increased NO production, indicating that NFAT5 plays a crucial role in modulating microglial responses to hyperosmotic stress." The study also highlighted the role of the NCX in this process.

Adding further, Prof. Sugimura says, "Hyperosmotic stress triggered Ca^{2+} efflux through NCX, contributing to elevated NOS2 expression and NO production." This finding aligns with previous research on macrophages revealing unique aspects of microglial physiology. Interestingly, this process seemed to operate independently of NFAT5, suggesting multiple activation pathways are involved in the microglial response to hyperosmotic stress.

Additionally, the researchers found that minocycline effectively inhibited NOS2 expression and NO production induced by hyperosmotic stress, suggesting its potential as a therapeutic strategy for managing conditions associated with elevated sodium levels. However, the inhibitory effect of minocycline appeared to be independent of NFAT5, indicating other underlying mechanisms.

Moving forward, the researchers recommend undertaking future investigations into the differences in microglial behavior under acute versus chronic hyperosmotic stress and the precise role of NFAT5 in these processes. Validating

these findings with animal models will provide a deeper understanding of hyperosmotic stress's impact on microglial function in more complex biological contexts.

Additionally, investigating other potential therapeutic agents and further examining how minocycline acts on microglia could lead to the development of more targeted and effective strategies to address electrolyte imbalances and their effects on neurological health.

In conclusion, these findings shed light on the cellular mechanisms of microglial activation in response to hyperosmotic stress, highlighting the roles of NFAT5 and NCX, and supporting the therapeutic potential of minocycline. The study provides valuable insights for researchers and clinicians tackling the challenges of neurological dysfunctions linked to hypernatremia.

More information: Sachiho Fuse et al, Effects of hypernatremia on the microglia, *Peptides* (2024). DOI: [10.1016/j.peptides.2024.171267](https://doi.org/10.1016/j.peptides.2024.171267)

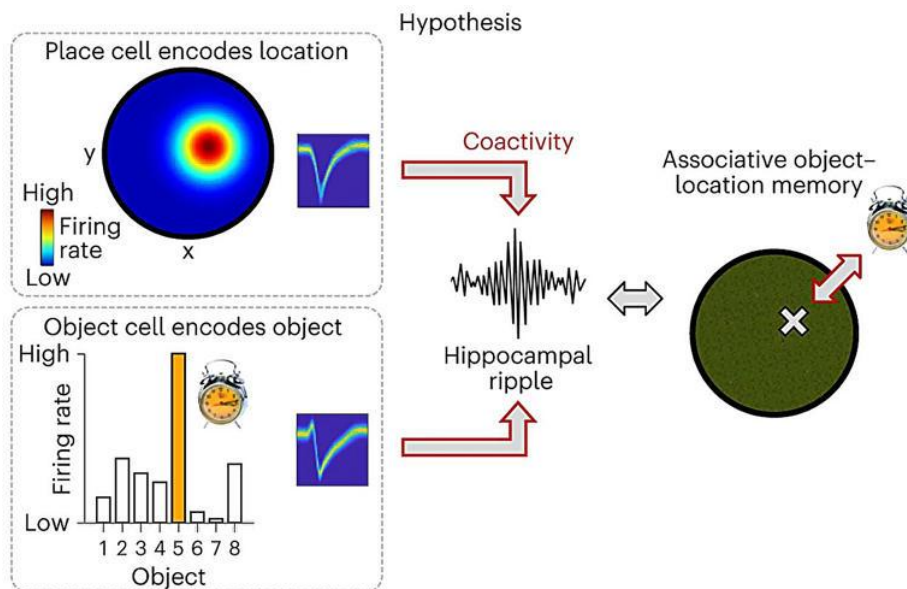


Illustration of the hypothesis that human associative object–location memory is linked to the coactivity of object cells and place cells during hippocampal ripples. We propose that the coactivity is specific to pairs of object and place cells that encode 'associative information', which are those cell pairs in which the location of the preferred object of the object cell is inside the place field of the place cell. Credit: Nature Neuroscience (2024). DOI: 10.1038/s41593-023-01550-x© Provided by Medical Xpress

Spatial navigation and spatial memory play a central role in our lives. Without these abilities, we would hardly be able to find our way around and it would be difficult to remember past events. However, the neuronal basis of spatial memory is far from being fully understood.

A research group led by Prof. Dr. Dr. Lukas Kunz, who has recently joined the University Hospital Bonn (UKB), has gained new insights into this gap in knowledge. Together with scientists from New York and Freiburg, he has discovered that different types of nerve cells become active together during spatial memory and are coordinated by brain waves ("ripples").

[These results](#) have now been published in the journal *Nature Neuroscience*.

Associative memory ensures that different pieces of information are linked together. "In the context of spatial memory, associative memory enables us to remember the locations of certain objects in the spatial environment," explains Prof. Kunz, research group leader for Cognitive and Translational Neuroscience at the Department of Epileptology at the UKB. He is also a member of the Transdisciplinary Research Area (TRA) Life & Health at the University of Bonn.

"For example, we can remember where in the house we put our keys." In older age or with certain diseases such as Alzheimer's, however, this ability is limited. "It is therefore important to investigate that the neuronal basis of different forms of human memory is researched further," says Prof. Kunz. In the long term, this could help in the development of new therapies for memory impairments.

Nerve cells play an important role in associative memory

Nerve cells are active while information is being retrieved from memory. To further investigate this phenomenon, the researchers recorded the activity of individual nerve cells in the brains of epilepsy patients while they performed a

memory task on the computer. "In a virtual world, the test participants were asked to remember the locations of various objects," explains Prof. Kunz.

The recordings showed that different types of nerve cells became active during this memory task. Some nerve cells responded to certain objects, while other nerve cells reacted in response to certain locations. The scientists observed that the interactions between these different types of nerve cells became stronger over time when the test participants remembered the right object in the right place.

Brain waves occur simultaneously, coordinate the nerve cells

In addition to place and object neurons, the researchers observed that hippocampal brain waves ("ripples") also became active during the memory task, and thus presumably play a crucial role in the formation and retrieval of associative memories.

"Ripples could be important for the connection of different types of nerve cells and the formation of complex memories. It will be exciting to investigate this idea further in future studies," explains Prof. Kunz. It will also be interesting in the future to study how memory performance is modulated when ripples are suppressed or even triggered, providing insights into the causal relevance of ripples.

More information: Lukas Kunz et al, Ripple-locked coactivity of stimulus-specific neurons and human associative memory, *Nature Neuroscience* (2024). DOI: [10.1038/s41593-023-01550-x](https://doi.org/10.1038/s41593-023-01550-x)

Provided by University Hospital of Bonn

A new study sheds light on how highly creative individuals, such as visual artists and scientists, may have brains that function differently compared to others. The research, published in *Psychology of Aesthetics, Creativity, and the Arts*, reveals that people who exhibit exceptional creativity—referred to as “Big C” creative individuals—demonstrate more random patterns of connectivity in their brains. By using functional MRI (fMRI) technology, the researchers observed that highly creative brains bypass typical neural hubs, making distant connections between different regions of the brain more quickly and efficiently.

The purpose of the study was to explore the biological foundations of exceptional creativity. Despite over seventy years of research on creative achievement, there has been limited data to support the biological mechanisms that differentiate highly creative individuals from others. Most studies of brain function in creativity have focused on everyday or professional-level creativity.

However, few have investigated what happens in the brains of those who make transformative, world-changing contributions in the arts and sciences—people often referred to as “Big C” creative types. These individuals are not only distinguished by their high levels of creative achievement but also by their ability to think in novel and non-linear ways.

The new study sought to fill the gap in understanding how the brains of these exceptional individuals work differently from both typical people and those who are merely highly intelligent. The researchers were specifically interested in how brain regions responsible for creativity, problem-solving, and artistic or scientific invention interact during tasks that demand creative thinking.

“I became interested in the topic of creativity because creativity is elusive,” said study author Ariana Anderson, an assistant research professor at the Semel Institute for Neuroscience and Human Behavior at UCLA. “People can be highly creative without being highly educated, yet most studies of creativity have compared highly intelligent and creative individuals with ‘garden variety’ average people.”

“This confound suggests that the studies might be identifying what makes some individuals more clever than others, but not necessarily more creative. Our study

compared creative people, who tend to be smarter than average, with garden variety smart people with equal intelligence.”

To investigate the neural basis of exceptional creativity, the research team recruited highly creative visual artists and scientists, as well as a comparison group of individuals matched for intelligence but not necessarily known for creative accomplishments. The study’s sample consisted of 66 participants: 21 Big C visual artists, 21 Big C scientists, and 24 “smart” individuals from the general population who served as a control group.

Each participant underwent brain scanning using fMRI technology, which measures brain activity by detecting changes in blood flow. The researchers captured brain connectivity both while participants were at rest and while they completed tasks designed to test their creative thinking. These tasks included:

- **The Alternative Uses Test**, which required participants to think of as many different uses as possible for a common object (for example, an umbrella).
- **The Remote Associates Test**, which presented three seemingly unrelated words and asked participants to find a fourth word that connected them (for example, the word “horse” connects the words “sea,” “rocking,” and “shoe”).

The researchers used a mathematical approach called graph theory to analyze the brain’s connectivity patterns. In this context, the brain’s regions were treated as “nodes,” and the connections between them as “edges.” The goal was to see how efficiently information flowed through these networks and whether Big C individuals exhibited distinct connectivity patterns compared to the control group.

During the resting-state scans, when participants were not engaged in any specific task, the Big C individuals showed more random patterns of brain connectivity compared to the control group. Specifically, they exhibited less “small-worldness”, a feature of brain networks that indicates an efficient balance between local and global connections. Instead of maintaining a highly organized structure, their brains displayed less clustering of connections between nearby regions, with more randomness overall.

However, locally, the creative individuals had increased clustering and efficiency, meaning certain brain areas were more specialized or active at rest. This suggests

that while their overall brain network was more random, specific regions were more densely connected, potentially preparing them for creative thinking.

During the Alternative Uses Test, the Big C individuals had lower local efficiency and clustering compared to the control group. In other words, their brain activity was less organized and efficient while performing the task, which aligns with the idea that their brains may function in a more exploratory and less constrained manner during creative tasks. This reduced local connectivity suggests that, instead of focusing on specific brain regions, the creative individuals' brains may adopt a more flexible approach, allowing for the generation of diverse and novel ideas.

"Our study found that creative individuals exhibited more random connectivity in their brains," Anderson told PsyPost. "This suggests that to be creative, we need to focus less and relax more. However, relaxing doesn't mean watching TikTok—it means resting our brains so they can generate their own internal content, rather than being influenced by external sources. In fact, our study showed the greatest differences in brain activity when creative individuals were doing nothing—not when they were actively trying to be creative or clever. Mind-wandering can be the optimal time for our creative brains to shine."

Interestingly, no significant differences in brain connectivity were found during the Remote Associates Test. The lack of differences during this task suggests that while the Big C individuals excel in making broad, random connections during divergent thinking, their brain connectivity during tasks that require finding one correct solution may be similar to that of non-creative individuals.

"The creative group did not show significant differences in verbal word-play tasks compared to the IQ-matched group," Anderson explained. "For example, if given the words 'house, horse, dragon,' both a creative and non-creative person would display similar brain activity when identifying the common word that links them ('fly')."

Despite these intriguing findings, the study has some limitations. One challenge in studying exceptional creativity is that it is difficult to recruit large samples of individuals who have achieved such high levels of success in their fields. As a result, the sample size in this study was relatively small, which limits the ability to detect more subtle differences between groups.

"Major caveats of our study include that we compared individuals already well-known for their creativity," Anderson noted. "It doesn't address the question of what makes some people highly creative, nor whether creativity is an inherent trait, or something that can be acquired or diminished. Many studies have shown that creativity rapidly diminishes in early childhood, so it's crucial to explore how cultural shifts in parenting and screen time may be stifling the creative potential of children."

"My long-term goals for this research are to determine how we can foster creativity in children. Do we become more creative through exposure to the arts or nature, or do we merely learn to mimic others' styles, thus limiting originality? How does screen time affect children's ability to generate new ideas, given that they are constantly exposed to repetitive content?"

"A 2019 study showed that [today's children are much less creative](#) than previous generations of children," Anderson added. "With post-COVID education being highly dependent on screens, it's likely this trend is worsening. This will inevitably result in decreased innovation from future generations, which could have economic consequences."

The study, "[Big-C Creativity in Artists and Scientists is Associated With More Random Global but Less Random Local fMRI Functional Connectivity](#)," was authored by Ariana Anderson, Kevin Japardi, Kendra S. Knudsen, Susan Y. Bookheimer, Dara G. Ghahremani, and Robert M. Bilder.

Noradrenergic neurons in the locus coeruleus (LC) play a key role in the transition from a focused to an alert state. The image shows these neurons in a mouse brain, revealed by immunohistochemical staining. Credit: UNIGE / ETH Zurich

W

hat enables the brain to go from intense concentration to a heightened state of alertness? A study carried out by neuroscientists at the University of Geneva (UNIGE), in collaboration with ETH Zurich, shows that a brain region called locus coeruleus (LC) and the neurotransmitter noradrenaline act as conductors, reorganizing brain functions according to the mental demands of the moment.

The study, [published](#) in *Nature Neuroscience*, demonstrates that the way the locus coeruleus is triggered enables us to switch from one state of concentration to another. This discovery could change the way elite sportsmen and women train to achieve their goals.

How do athletes achieve the extraordinary mental clarity and precision needed to succeed in their discipline? The answer lies in the brain's remarkable ability to focus, eliminating distractions to concentrate on a single task.

This phenomenon, often described as "being in the zone," is a critical skill not just for athletes, but for anyone facing a challenging task—whether it's taking an exam or mastering a musical instrument. At times, however, these people also need to be fully aware of their environment, especially when it comes to spotting potential dangers.

A handful of neurons

In this study, neuroscientists from UNIGE and ETH investigated what allows the brain to shift between intense focus and heightened awareness. The research team focused on the locus coeruleus (LC), a small region in the brainstem that produces noradrenaline, a neurotransmitter involved in regulating arousal.

"It's small and its location deep within the brain was a challenge from the outset, making it difficult to observe—and impossible to manipulate—in humans. For these reasons, we turned to mice where the LC consists of only about 3,000 neurons, but these neurons can still exert a significant influence over the 75 million neurons that make up the mouse brain," explains Valerio Zerbi, assistant professor in the Department of Psychiatry and the Department of Basic Neurosciences at the UNIGE Faculty of Medicine, and initiator of the study.

To overcome this challenge, his team collaborated with Johannes Bohacek's laboratory at ETH Zurich. Using advanced techniques such as optogenetics to artificially manipulate LC neurons and photometry to measure noradrenaline release, the researchers were able to explore LC function.

Functional Magnetic Resonance Imaging (fMRI) provided the first empirical evidence into how LC stimulation affects brain activity across different regions, shedding light on the LC's role in dynamically modulating attention and focus.

A question of rhythm

Neuroscientists discovered that triggering the LC three times a second in a continuous manner—so-called "tonic" activity—had different consequences than triggering the same frequency over a short period of time—so-called "burst" activity.

"When the LC is triggered in bursts, more noradrenaline is released, and the brain's sensory functions are prioritized. This sensory brain mode enables mice to be more alert to the environment around them," explains Zerbi.

Conversely, when the LC is triggered in a moderate tonic mode, less noradrenaline is released by the LC and brain regions such as the prefrontal cortex and hippocampus are activated. These two structures are known for processing information and are conducive to reflection and intense attention.

Controlling the locus coeruleus for performance

"While cutting-edge equipment and meticulous training are certainly part of the equation, the secret of top athletes may well lie in their mastery over their LC. By finely tuning its activity, they can switch between states of intense focus and broad awareness, performing at their peak when it matters most," concludes Zerbi.

Also, thanks to the findings of this study, brain imaging could help sportsmen and women to make better use of their LC, notably by using neurofeedback approaches, a technique that uses devices to monitor brain activity in real time to enable a person to regulate it based on visual feedback.

More information: Christina Grimm et al, Tonic and burst-like locus coeruleus stimulation distinctly shift network activity across the cortical hierarchy, *Nature*

Provided by University of Geneva

Understanding the link between brain activity and behavior is among the core interests of neuroscience. Having a better grasp of this relationship will both help scientists understand how the brain works on a basic level and uncover what specifically goes awry in cases of neurological and psychological disease.

One way that researchers study this connection is through what are known as "brain states," patterns of neural activity or connectivity that emerge during specific cognitive tasks and are common enough in all individuals that they become predictable. Another, newer, approach is the study of brain waves, rhythmic, repetitive patterns of brain cell activity caused by synchronization across cells.

In a new paper, two Yale researchers propose that these two ways of thinking about brain activity may not represent separate events but two aspects of the same occurrence. Essentially, they suggest that though brain states are traditionally thought of as a snapshot of brain activity while waves are more like a movie, they're capturing parts of the same story.

Reconsidering these two approaches in this context, the researchers say, could help both fields benefit from the methods and knowledge of the other and advance our understanding of the brain.

Inspired by ecological, conservation, and Indigenous philosophies, Maya Foster, a third-year Ph.D. student in the Department of Biomedical Engineering, began pursuing this idea once she joined the lab of Dustin Scheinost, an associate professor in the Department of Radiology and Biomedical Imaging at Yale School of Medicine.

They are co-authors of the [new paper](#), published in the journal *Trends in Cognitive Sciences*.

"We're arguing that rather than a brain state being one single thing, it's a collection of things, a collection of discrete patterns that emerge in time in a predictable way," she said.

In an interview with Yale News, Foster and Scheinost describe their proposal, and discuss how they might help researchers better understand the mysteries of the brain. This interview has been edited and condensed.

When did you start to consider these might be two aspects of the same occurrence?

Maya Foster: This has been on my mind even before I came to this lab. I was reading a book—"Erosion: Essays of Undoing" by Terry Tempest Williams—and she talks about how human-made machinery like helicopters cause vibrations that interrupt the natural pulse of things and cause things like rock formations to fall apart. Relatedly, there are a lot of Indigenous populations that believe everything has a pulse. And that got me thinking of the brain and whether we have some type of resonance or vibration that can be disrupted.

Then I joined this lab and Dustin let me experiment with a lot of different things. During one of those experiments, I input some data into a particular analysis and the outputs looked wave-like, and patterns emerged and then repeated. That took me down a whole rabbit hole of research literature and there was a lot of evidence for this idea of wave-like patterns in brain states.

What are the benefits of considering brain states as wave-like?

Foster: I think it creates a synergy where both sides—the brain state folks and the brain wave folks—benefit by learning from each other. And maybe the gaps in

knowledge we have now when it comes to how brain activity relates to behavior might be filled by both groups working together.

Dustin Scheinost: Brain waves are newer in this field and they're complex. And any time you can take something new and relate it to something old—brain states in this case—it gives you a natural jumping off point. You can bring along everything you've learned so far. It's kind of like not throwing the baby out with the bath water. We don't need to drop brain states. They've informed us, but we can go in a different direction with them too.

How are you proposing researchers consider brain states and brain waves now?

Foster: Borrowing from physics, when you analyze light, it can be a discrete point—a photon—or it can be wave-like. And that's one way we're thinking about this. Similarly, depending on how you analyze brain states you can get static patterns, much like a photon, or you if you look at activity more dynamically, certain patterns start to occur more than once over time, kind of like a wave.

So we're arguing that rather than a brain state being one single thing, it's a collection of things, a collection of discrete patterns that emerge in time in a predictable way.

For example, if we measured four distinct patterns in brain activity as someone completed a cognitive task, a brain state could be that pattern one emerges, then pattern three, then two, then four, and that series might repeat over time. And when that repetition stops, that would be the end of that particular brain state.

You also draw comparisons to the musical technique known as 'fugue.' How does that fit with how you're visualizing these phenomena?

Foster: I'm a music person, so that's where this came from. In a fugue, you have a basic melody and then that melody emerges later in the music in different forms and formats. For instance, the melody will play, then some other music comes in,

then the melody returns with the same rhythm and time sequence but maybe it's in a different key.

Fugues are cyclical and wave-like, they have distinct groups of notes, and there's a systematic repetition and sometimes layering of the main melody. We're arguing that brain states are also wave-like, have distinct patterns of brain activity, and display systematic repetition and layering of sequential patterns.

How are you hoping other researchers respond to your argument?

Foster: I would love feedback, honestly. There is evidence for what we're proposing but when it comes to implementing these ideas going forward, it would be helpful to have a conversation about how that might work. There are a lot of different strategies and I'm interested in a broader conversation about how we as researchers might go about studying this.

What's it like as someone who has been in this field for a while to have a student come in with a new idea like this?

Scheinost: You can get set in your ways as a researcher and you need new ideas, new creativity. Sometimes they may sound outlandish when you first hear them. But then you ruminate, and they start to take form. And it's fun. That's really where the fun of this job is, to hear new ideas and see how people discuss and debate them.

More information: Maya Foster et al, Brain states as wave-like motifs, *Trends in Cognitive Sciences* (2024). DOI: [10.1016/j.tics.2024.03.004](https://doi.org/10.1016/j.tics.2024.03.004)

Provided by Yale University

- *A regular exercise routine may boost your brain health for years, new research says.*
- *A study in the journal Aging and Disease saw increased cognition and production of neurons in the hippocampus.*
- *The study followed 151 healthy 65- to 85-year-olds for five years after they went through a six-month exercise program.*

Research has repeatedly [found](#) that having a regular exercise routine can do your health a solid. But a new study found it may help boost your brain health for years to come.

That's the major takeaway from a new study published in the medical journal [Aging and Disease](#). For the study, researchers followed 151 healthy 65- to 85-year-olds as they went through a six-month exercise program. The participants went through a slew of tests along the way, including biomarker and cognitions tests, along with brain scans.

From there, they were followed for five years. The researchers discovered that the participants got a boost in [cognition](#)—that is, mental processes in the brain like thinking, attention, language, learning, memory, and perception—from the exercise. And, the effects stuck around for five years.

The study had participants do three exercise intensities: Low-intensity exercises like balance and stretching; medium-intensity exercises like brisk walking on a treadmill; and high-intensity exercises like running hard on a treadmill. Ultimately, they discovered that the high-intensity exercise was best.

"Six months of high-intensity interval training is enough to flick the switch," study co-author [Perry Bartlett](#), a professor emeritus at the University of Queensland, said in a [statement](#).

The researchers also found that exercise increased the production of neurons in the hippocampus, an area of the brain that's involved in memory, learning, and emotion. As a result, it improved cognition.

"Exercise-based interventions can provide significant protection against hippocampal cognitive decline in the aged population," the researchers concluded in the study.

The researchers are hoping that their findings will help doctors create meaningful exercise plans for older adults.

"Our finding can inform exercise guidelines for older people and further research could assess different types of exercise that could be incorporated into aged care," [Daniel Blackmore](#), PhD, a research fellow at the University of Queensland's Queensland Brain Institute, said in a [statement](#).

In the future, the researchers also looking to see if there are certain genetic factors that makes someone more likely to get the best brain boost from high-intensity exercises.

By the way, if you want to tap into the mental health perks of high-intensity interval training, these [HIIT exercises](#) can help to get you started.

Try 200+ at home workout videos from Men's Health, Women's Health, Prevention, and more on [All Out Studio](#) free for 14 days!

There lies a paradox in sleep. Its apparent tranquility juxtaposes with the brain's bustling activity. The night is still, but the brain is far from dormant. During sleep, brain cells produce bursts of electrical pulses that cumulate into rhythmic waves—a sign of heightened brain cell function.

But why is the brain active when we are resting?

Slow brain waves are associated with restful, refreshing sleep. And now, scientists at Washington University School of Medicine in St. Louis have found that brain waves help flush waste out of the brain during sleep. Individual nerve cells coordinate to produce rhythmic waves that propel fluid through dense brain tissue, washing the tissue in the process.

"These neurons are miniature pumps. Synchronized neural activity powers fluid flow and removal of debris from the brain," explained first author Li-Feng Jiang-Xie, Ph.D., a postdoctoral research associate in the Department of Pathology & Immunology.

"If we can build on this process, there is the possibility of delaying or even preventing neurological diseases, including Alzheimer's and Parkinson's disease, in which excess waste—such as metabolic waste and junk proteins—accumulate in the brain and lead to neurodegeneration."

Brain cells orchestrate thoughts, feelings and body movements, and form dynamic networks essential for memory formation and problem-solving. But to perform such energy-demanding tasks, brain cells require fuel. Their consumption of nutrients from the diet creates metabolic waste in the process.

"It is critical that the brain disposes of metabolic waste that can build up and contribute to neurodegenerative diseases," said Jonathan Kipnis, Ph.D., the Alan A. and Edith L. Wolff Distinguished Professor of Pathology & Immunology and a BJC Investigator. Kipnis is the senior author on the paper.

"We knew that sleep is a time when the brain initiates a cleaning process to flush out waste and toxins it accumulates during wakefulness. But we didn't know how that happens. These findings might be able to point us toward strategies and potential therapies to speed up the removal of damaging waste and to remove it before it can lead to dire consequences."

But cleaning the dense brain is no simple task. Cerebrospinal fluid surrounding the brain enters and weaves through intricate cellular webs, collecting toxic waste as it travels. Upon exiting the brain, contaminated fluid must pass through a barrier before spilling into the lymphatic vessels in the dura mater—the outer tissue layer enveloping the brain underneath the skull. But what powers the movement of fluid into, through and out of the brain?

Studying the brains of sleeping mice, the researchers found that neurons drive cleaning efforts by firing electrical signals in a coordinated fashion to generate rhythmic waves in the brain, Jiang-Xie explained. They determined that such waves propel the fluid movement.

The research team silenced specific brain regions so that neurons in those regions didn't create rhythmic waves. Without these waves, fresh cerebrospinal fluid could not flow through the silenced brain regions and trapped waste couldn't leave the brain tissue.

"One of the reasons that we sleep is to cleanse the brain," Kipnis said.

"And if we can enhance this cleansing process, perhaps it's possible to sleep less and remain healthy. Not everyone has the benefit of eight hours of sleep each night, and loss of sleep has an impact on health. Other studies have shown that mice that are genetically wired to sleep less have healthy brains. Could it be because they clean waste from their brains more efficiently? Could we help people living with insomnia by enhancing their brain's cleaning abilities so they can get by on less sleep?"

Brain wave patterns change throughout sleep cycles. Of note, taller brain waves with larger amplitude move fluid with more force. The researchers are now interested in understanding why neurons fire waves with varying rhythmicity during sleep and which regions of the brain are most vulnerable to waste accumulation.

"We think the brain-cleaning process is similar to washing dishes," neurobiologist Jiang-Xie explained.

"You start, for example, with a large, slow, rhythmic wiping motion to clean soluble wastes splattered across the plate. Then you decrease the range of the motion and increase the speed of these movements to remove particularly sticky food waste on the plate. Despite the varying amplitude and rhythm of your hand movements, the overarching objective remains consistent: to remove different types of waste from dishes. Maybe the brain adjusts its cleaning method depending on the type and amount of waste."

More information: Jonathan Kipnis, Neuronal dynamics direct cerebrospinal fluid perfusion and brain clearance, *Nature* (2024). DOI: [10.1038/s41586-024-07108-6](https://doi.org/10.1038/s41586-024-07108-6). www.nature.com/articles/s41586-024-07108-6

Provided by Washington University School of Medicine

Ultraslow oscillations in MEC neurons. a, Neural activity was recorded through a prism from GCaMP6m-expressing neurons of the MEC in head-fixed mice running in darkness on a non-motorized wheel. Cartoon of a running mouse on the right created with BioRender.com. b, Stacked z-scored autocorrelations of single-cell calcium activity for one example session (484 neurons), plotted as a function of time lag. Neurons are sorted according to the maximum power of the PSD calculated on each autocorrelation separately, in descending order. c, PSD (left) calculated on the autocorrelation (right) of one example cell's calcium activity. The dashed red line indicates the frequency at which the PSD peaks (0.0066 Hz). d, As in c but for another example cell. The PSD peaks at 0.0066 Hz and has harmonics at 0.0132, 0.0207 and 0.0273 Hz. e,f, As in c,d but for two example cells recorded using Neuropixels probes. The PSDs peak at 0.016 Hz (e) and 0.015 Hz (f). Credit: Nature (2023). DOI: 10.1038/s41586-023-06864-1 © Provided by Medical Xpress

Scientists at NTNU's Kavli Institute for Systems Neuroscience in Norway have discovered a pattern of activity in the brain that serves as a template for building sequential experiences.

"I believe we have found one of the brain's prototypes for building sequences," says Professor Edvard Moser. He describes the activity pattern as "a fundamental algorithm that is intrinsic to the brain and independent of experience."

The breakthrough discovery was [published in Nature](#).

The ability to organize elements into sequences is a fundamental biological function essential for our survival. Without it, we would not be able to communicate, keep track of time, find our way, or even remember what we are in the process of doing. The world would cease to present itself to us in meaningful experiences, as every event would be fragmented into an erratic series of random happenings.

The NTNU researchers' discovery of a rigid sequence pattern in the brain provides new insights into how we organize experiences into a temporal order.

The sequential nature of memory

Have you ever heard memories described as snapshots? That is not a very faithful description, according to Professor Edvard Moser. "It is more helpful to think of memories as videos," he says.

"All your experiences in the world extend over time," says Professor May-Britt Moser. "One thing happens, then another thing, then a third."

Your brain has the remarkable ability to mentally capture and organize selected events into the chronological order in which they occurred, and to link them together as meaningful experiences. This sequence-building activity takes place on the timescale in which you interact in the situation. When you recall this memory, the process of reliving the sequence of events in your mind also takes time.

"How is the brain able to generate and store all these unique and lengthy sequences of information on the fly?" asks Edvard Moser.

"There has to exist a foundational mechanism for sequence formation there."

"There is a mismatch in neuroscience between the timescales at which brain activity is typically studied, in the millisecond regime, and the timescales at which many of our most important brain functions occur, in the tens of seconds to several minutes range," says Soledad Gonzalo Cogno, Kavli Research Group Leader and first author of the paper, expanding on the motivation behind this study.

The team set out to identify this fundamental mechanism for sequence formation, which occurs on very slow timescales as most of our brain functions do.

The experiment

To uncover how neurons coordinate at the slow timescales at which many of our brain functions unfold, the Kavli researchers focused on the medial entorhinal cortex (MEC), a brain area that supports brain functions that depend on sequence formation, such as navigation and episodic memory, which unfold very slowly in time.

The sheer volume of information about the outside world being processed in the brain at any one time posed a challenge to the pursuit. Any baseline signal from structured and recurrent neural algorithms would risk drowning in the "noise" of incoming experience.

To get around this, the researchers created an experimental environment that was almost devoid of sensory inputs. They let a mouse run in complete darkness, with no task to complete and no reward to earn. The mouse could run or rest as it pleased for as long as the session lasted.

At the same time, the researchers recorded what was happening in the entorhinal cortex of the mouse's brain while its orchestra of nerve cells remained in this soft-spoken standby position.

A fundamental brain mechanism for sorting information into sequences

"This is what we found," says Soledad Gonzalo Cogno, pointing to a zebra-striped figure before her.

The pattern is made up of thousands of dots clustered together. Each dot is a neural signal. We can see that the neural activity moves through all the cells from bottom to top along the Y-axis as time progresses along the X-axis. The clustering tells us that the activity is coordinated as waves running through the network, like rhythms in a symphony.

The sequences are ultra-slow, meaning that it takes two minutes for the wave to travel through the neural network, before the whole process repeats again, sometimes for as long as the duration of the test session, over periods of up to an hour.

The figure shows several hundred mouse entorhinal cortex neurons oscillating at ultra-slow frequencies, spanning time windows ranging from tens of seconds to several minutes. The dynamic that excited the researchers, even more, is that as each cell oscillates, the cells also organize themselves into sequences, with cell A firing before cell B, cell B firing before cell C, and so on, until they have completed a full loop and return to cell A, where the cycle repeats.

This highly structured activity overlaps with the timescale of events that we encode into our memories and provides the perfect template for building the sequential structure that forms the basis of episodic memories.

These waves of coordinated activity did not travel straight from one end of the brain tissue to the other. Instead, the waves travel along the thin synaptic connections between cells that talk to each other in the network. Cells can talk to other cells far away and to their nearest neighbors. The anatomical tangle makes it difficult to see coordinated activity with the naked eye without first locating the cells from the raster plot.

Zebra-stripes, spiral, and ring

The zebra-striped raster plot shows the slow waves of activity through the whole network over a period of time. "If you fold the raster plot into a tube so that the top and the bottom of the figure overlap, you will see that the diagonal stripes connect to form a coherent spiral," explains May-Britt Moser. "The spiral represents the network activity over time."

You will see a ring if you rotate the spiral by 90 degrees. All the cells in the network have their set time to fire, distributed across the surface of this ring. The signal travels through the entire ring structure before returning to the same cell.

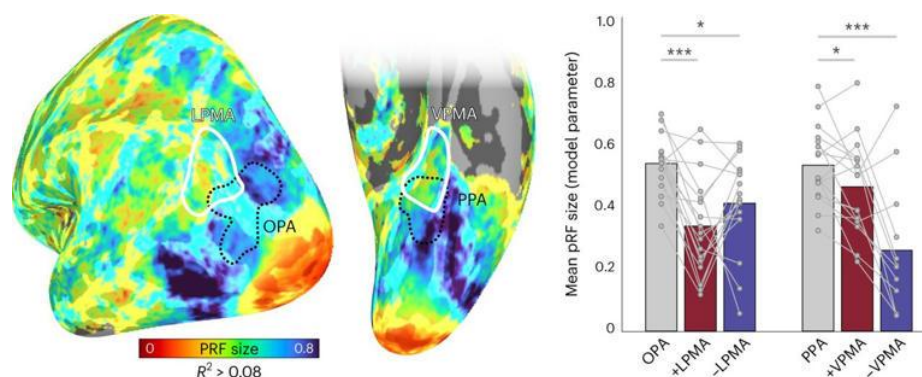
"This ring is a signature for coordination patterns in the form of repetitive sequences, which is what we found in the MEC," says Soledad Gonzalo Cogno. "Other brain areas have different coordination patterns."

Your brain may already be equipped with this ring before you experience anything in this world. It is acquired through evolution and may be specified in our genes.

"What excites me most about this discovery is the prospect that these sequences may open up for new ways of understanding the brain," says Gonzalo Cagno. "The discoveries that follow may challenge the way we think about coordination throughout the brain. Cells that are so different still seem to be coordinated and work together on different timescales."

More information: Edvard Moser, Minute-scale oscillatory sequences in medial entorhinal cortex, *Nature* (2023). DOI: [10.1038/s41586-023-06864-1](https://doi.org/10.1038/s41586-023-06864-1). www.nature.com/articles/s41586-023-06864-1

Provided by Norwegian University of Science and Technology



Memory areas contain smaller pRFs compared to their paired perceptual areas. Left, group average pRF size with memory areas and perception areas overlaid. Nodes are threshold at $R^2 > 0.08$. Right, bars represent the mean pRF size for +pRFs in SPAs (OPA, PPA) and +/-pRFs in PMAs (LPMA, VPMA). Individual data points are shown for each participant. Across both surfaces, pRFs were significantly smaller on average in the PMAs than their perceptual counterparts. Credit: Nature Neuroscience (2024). DOI: [10.1038/s41593-023-01512-3](https://doi.org/10.1038/s41593-023-01512-3) © Provided by Medical Xpress

Our memories are rich in detail: we can vividly recall the color of our home, the layout of our kitchen, or the front of our favorite café. How the brain encodes this information has long puzzled neuroscientists.

In a new Dartmouth-led study, researchers identified a neural coding mechanism that allows the transfer of information back and forth between perceptual regions to memory areas of the brain. The results are published in [Nature Neuroscience](#).

Prior to this work, the classic understanding of brain organization was that perceptual regions of the brain represent the world "as it is," with the brain's visual cortex representing the external world based on how light falls on the retina, "retinotopically." In contrast, it was thought that the brain's memory areas represent information in an abstract format, stripped of details about its physical nature. However, according to the co-authors, this explanation fails to take into account that as information is encoded or recalled, these regions may in fact, share a common code in the brain.

"We found that memory-related brain areas encode the world like a 'photographic negative' in space," says co-lead author Adam Steel, a postdoctoral researcher in the Department of Psychological and Brain Sciences and fellow in the Neukom Institute for Computational Science at Dartmouth. "And that 'negative' is part of the mechanics that move information in and out of memory, and between perceptual and memory systems."

In a series of experiments, participants were tested on perception and memory while their brain activity was recorded using a functional magnetic resonance imaging (fMRI) scanner. The team identified an opposing push-pull like coding mechanism, which governs the interaction between perceptual and memory areas in the brain.

The results showed that when light hits the retina, visual areas of the brain respond by increasing their activity to represent the pattern of light. Memory areas of the brain also respond to visual stimulation, but, unlike visual areas, their neural activity decreases when processing the same visual pattern.

The co-authors report that the study has three unusual findings. The first is their discovery that a visual coding principle is preserved in memory systems.

The second is that this visual code is upside-down in memory systems. "When you see something in your visual field, neurons in the visual cortex are driving while those in the memory system are quieted," says senior author Caroline Robertson, an assistant professor of psychological and brain sciences at Dartmouth.

Third, this relationship flips during memory recall. "If you close your eyes and remember that visual stimuli in the same space, you'll flip the relationship: your

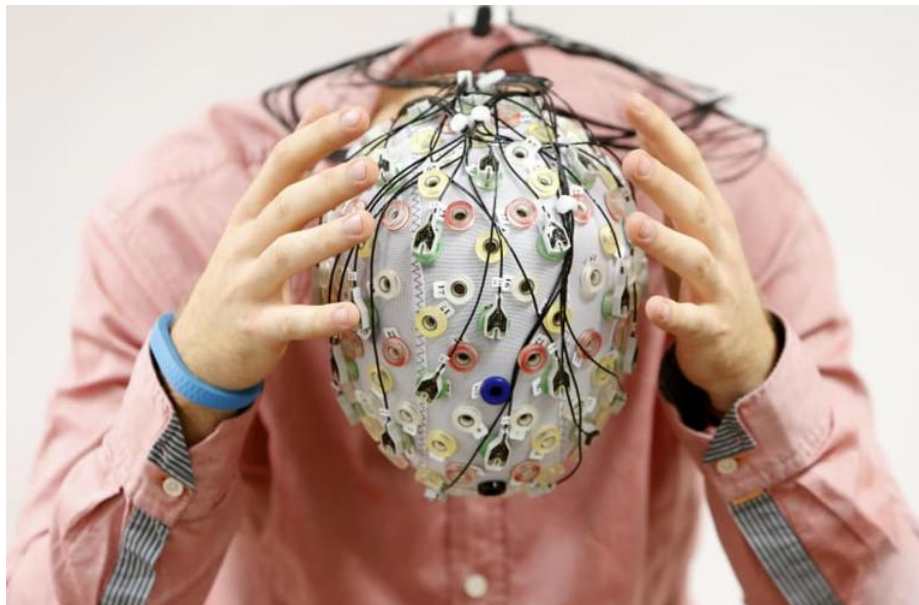
memory system will be driving, suppressing the neurons in perceptual regions," says Robertson.

"Our results provide a clear example of how shared visual information is used by memory systems to bring recalled memories in and out of focus," says co-lead author Ed Silson, a lecturer of human cognitive neuroscience at the University of Edinburgh.

Moving forward, the team plans to explore how this push and pull dynamic between perception and memory may contribute to challenges in clinical conditions, including in Alzheimer's.

More information: Adam Steel et al, A retinotopic code structures the interaction between perception and memory systems, *Nature Neuroscience* (2024). DOI: [10.1038/s41593-023-01512-3](https://doi.org/10.1038/s41593-023-01512-3)

Provided by Dartmouth College



Test person Niklas Thiel poses with an electroencephalography (EEG) cap which measures brain activity, at the Technische Universität München (TUM) in Garching near Munich© (photo credit: REUTERS/Michaela Rehle)

Understanding how the brain encodes information is important to understand how parts of the body “communicate” with the brain – for example, if

doctors want to connect a prosthetic hand or leg to the brain and let the brain operate it.

“Understanding the language that the brain uses to speak to itself will enable us to better understand how to transfer information to and [from the brain](#) with a high degree of precision,” according to Prof. Eran Stark of the Sagol neurobiology department at [the University of Haifa](#) who led a study just published in the prestigious journal *Science* under the title “Local activation of CA1 pyramidal cells induces theta-phase precession.”

To encode new information, brain cells in the hippocampus – a complex brain structure embedded deep into the temporal lobe that has a major role in learning and memory – activate a mechanism that triggers an increase in the firing rate and influences the precise timing of the firing.

The importance of understanding the brain

“The new study shows us that local circuits in the brain are more sophisticated than we might have thought. The brain can encode information in two different ways, one of which causes the other,” Stark explains.

The question of how the brain encodes new information it receives is one of the most important and complex issues in understanding processes of learning, memory, and more.

Illustration of a brain. (credit: INGIMAGE)© Provided by The Jerusalem Post

Illustration of a brain. (credit: INGIMAGE)

One of the main problems involved in understanding coding mechanisms concerns the difficulty in “controlling” neurons and making them act in a particular manner.

Until now, neurobiologists knew that during the encoding of new information (specifically, the identification by mice of new places within space), neurons in the hippocampus participate in two processes.

What are the two processes that occur?

The first process entails an increase in the firing rate of the individual cell.

In simple terms, the cell fires more times within a given period of time. The second process is a change in the timing mechanism. Theta waves with a frequency of 8 Hertz occur in the hippocampus, and it is possible to measure precisely when within the shape of the theta wave the cell fires – at what timing (phase) “along the wave.”

In the second process, when entering a new place in space, the neurons initially fire at the peak of the wave, then at an earlier phase, and on leaving the new place, they again fire close to the peak of the wave – a process known as phase precession.

According to the current state of knowledge, both of these processes occur simultaneously in the same cell in mice during the encoding of new information concerning spatial location.

Until now, however, it was not known whether there is a causal relationship between the two processes – does one cause the other or do they operate independently? In addition, if there is a causal dependence between the two processes, it has been unclear what mechanism promotes the conversion of the code for the firing rate into a temporal code for phase precession, causing the two to operate simultaneously.

Over the years, six groups of mathematic models were proposed, each assuming a different mechanism for the relationship between the two processes.

A new study at Tel Aviv University

In the new study – which was headed by Stark while he was the head of the Center of Excellence for the Study of the Neural Code underlying Cognition [at Tel Aviv University TAU](#), the researchers used optogenetic technology that uses a special protein channel that reacts to light: each time the protein is exposed to blue light, the electric potential inside the neuron changes and it fires.

The researchers implanted miniaturized optoelectronic devices in the brains of freely moving mice and, using closed-loop feedback methods, caused an individual cell in the hippocampus to increase its firing rate artificially – the condition for the first process of information encoding.

The researchers monitored the mouse as it moved back and forth along a track – as it used coding mechanisms for spatial recognition.

In some track crossings, the researchers caused an increase in the firing rate of the examined cell in the hippocampus, and in others, they did not.

This allowed them to examine the effect of the artificial constraint on the firing rate at different points and times and under different conditions and thereby compare their results to “control” instances.

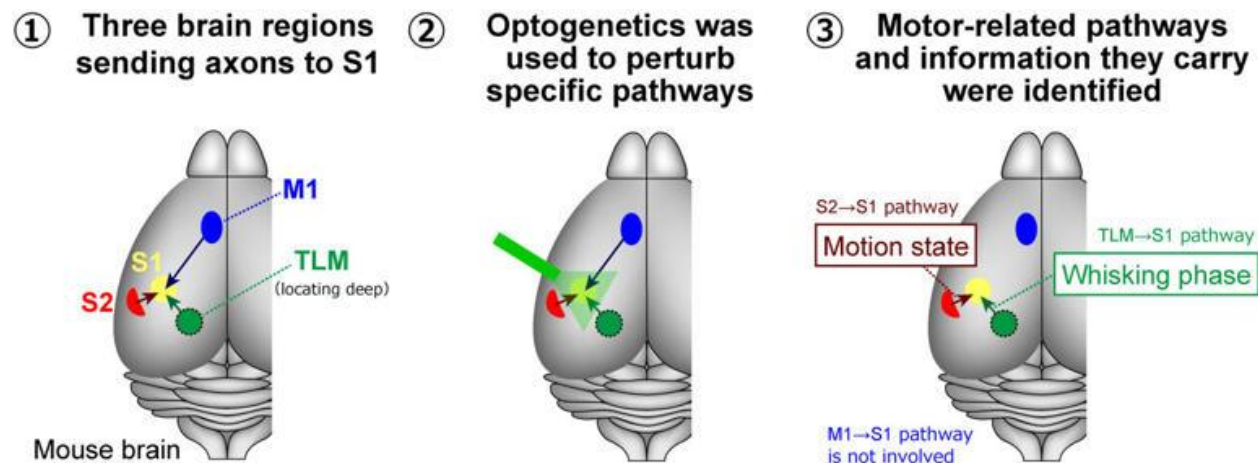
The findings showed that when the researchers increased the cell firing rate and created a new rate code, a change occurred in the precise timing of firing, and a phase code emerged. When the firing rate was not increased, no change in timing was observed. Thus, a clear causal relationship could be seen, whereby increasing the rate causes a change in timing.

“Firstly, it is important to clarify that although we examined the six existing model groups, there may, of course, be additional explanations we did not consider that are correct,” Stark stressed.

“If we wish to elaborate the model that explains the observations, we need to understand where the additional wave that causes interference comes from. For there to be a new wave, there must be an additional oscillator – something that creates the oscillations that form the faster waves,” Stark added.

“Regarding the practical ramifications of understanding the brain mechanism for the first time, Stark said that for us to communicate effectively with the brain, we need to use its own language (code). Before our study, it might have been assumed that the brain uses several separate systems to operate the two codes simultaneously –that the brain uses several languages. But now we know that at least in one area of the brain, one code – the rate code – can be automatically converted into a code for precise timing that may be better suited to the transmission of information between the cells but is harder to implement

artificially. So, if we want to elaborate the model that explains the observations, we need to understand where the additional wave that causes interference comes from," he concluded.



Utilizing optogenetics, researchers at Fujita Health University have selectively deactivated neural pathways with light, revealing new insights into how sensory and motor areas of the mouse brain communicate during movement. Credit: Takayuki Yamashita from Fujita Health University© Provided by Medical Xpress

Our body movements profoundly impact how our brain processes sensory information. Historically, it was believed that the brain's primary motor cortex played a key role in modulating sensory experiences during movement. However, a new study led by researchers from Fujita Health University has challenged this view.

By selectively inhibiting different neural pathways in the mouse brain, they discovered that regions beyond the primary motor cortex significantly influence the primary sensory cortex during movement.

The brain is widely considered the most complex organ in the human body. The intricate mechanisms through which it processes sensory information and how this information affects and is affected by motor control have captivated neuroscientists for more than a century. Today, thanks to advanced laboratory tools and techniques, researchers can use animal models to solve this puzzle, especially in the mouse brain.

During the 20th century, experiments with anesthetized mice proved that sensory inputs primarily define neuronal activity in the primary sensory cortices—the brain regions processing sensory information, including touch, vision, and audition.

However, over the past few decades, studies involving awake mice revealed that spontaneous behavior, such as exploratory motion and movement of the whiskers called whisking, actually regulates the activity of the sensory responses in the primary sensory cortices. In other words, sensations at the neuronal level appear substantially modulated by body movements, even though the corresponding neuronal circuits and the underlying mechanisms are not fully understood.

To address this knowledge gap, a research team from Japan investigated the primary somatosensory barrel cortex (S1)—a region of the mouse brain that handles tactile input from the whiskers. Their latest study, [published in *The Journal of Neuroscience*](#) was conducted by Professor Takayuki Yamashita from Fujita Health University (FHU) and Dr. Masahiro Kawatani, affiliated with FHU and Nagoya University, along with their team.

The S1 region receives input through the axons from several other areas, including the secondary somatosensory cortex (S2), the primary motor cortex (M1), and the sensory thalamus (TLM).

To investigate how these regions modulate activity in S1, the researchers turned to optogenetics (a technique for controlling activities of specific neuronal populations by light) involving eOPN3, which is a recently discovered light-sensitive protein enabling effective inhibition of specific neural pathways in response to light. Using viruses as a vector, they introduced the gene coding for this protein into the M1, S2, and TLM regions in mice.

Then, they measured neural activity in S1 in awake mice performing spontaneous whisking. During this process, they selectively inhibited different signal inputs going to S1 using light as an ON/OFF switch and observed the effect at S1.

Interestingly, only signal inputs from S2 and TLM to S1, not from M1 to S1, modulated neuronal activity in S1 during spontaneous whisking. Specifically, the

pathway from S2 to S1 seems to convey information about the motion state of the whiskers.

Additionally, the TLM-to-S1 pathway appeared to relay information related to the phase of spontaneous whisking, which follows a repetitive and rhythmic pattern.

These results challenge the established view that neuronal activity in sensory cortices is modulated primarily by motor cortices during movement; as Prof. Yamashita remarks, "Our findings provoke a reconsideration of the role of motor-sensory projections in sensorimotor integration and bring to light a new function for S2-to-S1 projections."

A better understanding of how distinct brain regions modulate activities among each other in response to movement could lead to progress in myriad applied fields. These research insights have far-reaching implications, potentially revolutionizing fields like artificial intelligence (AI), prosthetics, and brain-computer interfaces.

"Understanding these neural mechanisms could greatly enhance the development of AI systems that mimic human sensory-motor integration and aid in creating more intuitive prosthetics and interfaces for those with disabilities," Prof. Yamashita adds.

In summary, this study sheds light on the intricate workings of the brain. It also paves the way for researching the connection between body motion and sensory perception. As we continue to explore brain-related enigmas, studies like this offer vital clues in our quest to understand the most complex organ in the human body.

More information: Masahiro Kawatani et al, Interareal synaptic inputs underlying whisking-related activity in the primary somatosensory barrel cortex, *The Journal of Neuroscience* (2023). DOI: [10.1523/JNEUROSCI.1148-23.2023](https://doi.org/10.1523/JNEUROSCI.1148-23.2023)

Provided by Fujita Health University

In his later life, my father-in-law routinely woke up for the day at 3 a.m. He'd become such an early bird that he morphed into a night owl, a man resigned to a post-retirement inability to clock in more than four or five hours of rest. I can recall taking his routines as a grim prophecy. And when a few years later I found myself struggling with brutal bouts of insomnia, I wondered if, along with laugh lines and macular degeneration, sleeplessness was an inevitable part of growing older for me, too.

There is a persistent folk wisdom that older people simply don't need as much sleep — an idea likely borne out of the idea that as our lifestyles ostensibly become less active, our requirements for the reparative benefits of rest diminish. As recently as 2008, a report in [Current Biology](#) found that in one experiment, older subjects got 1.5 hours less sleep on average than their younger counterparts. "The most parsimonious explanation for our results," researcher Elizabeth Klerman of Brigham and Women's Hospital & Harvard Medical School said at the time, "is that older people need less sleep."

But what we *need* and what we actually *get* are two entirely different entities — and we are in the midst of a sleep shortage that's affecting Americans across all generational lines. The CDC notes that "[A third of US adults report that they usually get less than the recommended amount of sleep.](#)" It's [a crisis that can wreak havoc](#) on our physical and mental health, with sleep deprivation contributing to obesity, hypertension, diabetes, depression and stroke. And even accounting for fluctuations among different age populations, [most adults need between 7 and 9 hours of sleep per night](#). The key is just staying in a healthy range.

[Dr. Ryan Sultan](#), a board-certified psychiatrist, therapist, researcher and professor at Columbia University, says that "As we age, the amount of sleep needed tends to decrease. Older adults may be well-rested and alert after 6 to 7 hours."

My late father-in-law may not have had much steam in him after dinnertime, but his days were as active and engaged as his solitary predawn hours. Sultan says it's just about paying attention to overall health patterns and any changes that feel off. "In my clinical experience," he says, "I have observed that older adults often face unique challenges, such as medical conditions or medications affecting

sleep. Addressing these factors with a healthcare professional is crucial for developing a tailored approach to sleep improvement."

As Sultan puts it, "The concept of normal sleep does change as we age, and recognizing these shifts is essential for maintaining optimal health."

The real culprit to watch out for as we age isn't the amount of sleep, but quality of it. Older people have unique vulnerabilities around getting a deep, steady rest. A 2017 analysis in the journal [Sleep Medicine Clinics](#) explained how so-called "sleep architecture" can change with age, including "advanced sleep timing, shortened nocturnal sleep duration, increased frequency of daytime naps, increased number of nocturnal awakenings and time spent awake during the night, decreased slow wave sleep, and other changes."

Auckland sleep psychologist [Dan Ford, clinical director of the Better Sleep Clinic](#), puts it simply, "Generally speaking, sleep ability declines as we age as the mechanisms that control sleep become less robust over time." But nothing is set in stone. He adds, "Healthy older adults do not necessarily show these changes in their sleep parameters."

Why do those gorgeous, lengthy sleeps of our younger years become so elusive as we age? There are a whole litany of reasons. [There's menopause](#), with its discomforts and night sweats. Bathroom issues can likewise keep a person of any gender up and down all night long. Changes in the urinary tract, along with other factors like bladder obstruction, make nocturia (frequent nighttime urination) [far more common](#) in adults over the age of 60.

There are other physical factors as well — the National Council on Aging estimates that "[56% of people](#) age 65 and older have a high risk of developing obstructive sleep apnea." Our [circadian rhythms also change as we age](#), edging us to what can make us feel like we're living in a different time zone from our family and friends. And then there are the mental health issues. Grief, loneliness, financial loss and other stressors can wreck a good night's rest, and the symptoms of [depression and anxiety often go undiagnosed](#). A 2018 study on insomnia in the Journal of Clinical Sleep Medicine found that "[As many as 50% of older adults complain about difficulty initiating or maintaining sleep.](#)"

So if you're noticing that your nights now typically involve periods of wakefulness, is playing a little catch up when possible during the day a good idea?

"Napping can be a helpful strategy for older adults," says Dr. Ryan Sultan, "but the timing and duration matter. Short naps of around 20 to 30 minutes can boost alertness without interfering with nighttime sleep. However, extended or late-afternoon naps might disrupt the sleep-wake cycle, making it harder to fall asleep at night." Mileage can vary even there, though — I have a friend in his late 50s who regularly konks out before making dinner. He calls it a "nappetizer."

For those who have a hard time resisting longer naps, [Rod Mitchell](#), a Calgary psychologist with expertise in cognitive behavioral therapy for insomnia, recommends offsetting grogginess with a "coffee nap." He says, "Combine a small, controlled intake of caffeine (such as a half cup of coffee) followed by a short, 20-minute nap. This method can enhance the restorative effect of napping, with the caffeine kicking in just as you wake up, potentially offering a more refreshing experience."

However many candles may be on your own next birthday cake, we all need to prioritize adequate rest. We know that building healthy routines like regular bedtimes, avoiding too much caffeine and late-night doomscrolling or binge-watching and getting adequate physical activity are the best bet for a better night — even if it's all easier said than done. Our culture typically regards aging as a failure and sleep as for the weak. But the plain fact is that our bodies change over time. That doesn't mean that once you hit your AARP era, you suddenly can function just fine on 5 hours of sack time. Instead, if you want to feel younger, you just might actually need to sleep more.

Credit: Pixabay/CC0 Public Domain© Provided by Medical Xpress

Research into how the human brain stores information could lead to treatments for people who struggle with everyday tasks.

Professor Jan Buitelaar, an expert in neurodevelopmental illnesses, is intrigued by a possible link between attention deficit hyperactivity disorder—or ADHD—and memory.

While genes play a big part in ADHD, Buitelaar thinks the recordkeeping part of the brain known as "working memory" does too. Working memory holds a limited amount of information such as a street address or phone number for a brief time while providing a fundamental base for higher mental processes like decision-making.

Storage test

"When a teacher explains something to a pupil, the child is expected to keep much of that information active in their mind and also to integrate it with facts and knowledge stored elsewhere in the brain," said Buitelaar, who conducts research at the Radboud University Medical Center in the Netherlands. "These functions are carried out by working memory."

Now, a new project is seeking to shed new light on links between mental illnesses such as ADHD and working memory.

While ADHD affects millions of people in Europe, it is far from being the only neurological condition associated with working-memory deficits.

"Working memory can be compromised in many disorders—from schizophrenia to Alzheimer's disease and Parkinson's—but also in healthy aging," said Dr. Bernhard Spitzer, a cognitive neuroscientist at the Max Planck Institute for Human Development in Germany. "So understanding it better is very important."

Spitzer leads the EU project, which is called DeepStore and runs for five years through 2026.

Although working memory has very limited capacity—at any given time, it can accommodate just four to seven pieces of information—it is essential for normal human functioning and represents what Spitzer calls a "superpower."

Nimble wonder

When working memory underperforms, people lose track of what they did moments after doing it—for instance, forgetting that they put a towel into a gym bag straight after zipping it up.

"If your attention skills are weak, you have constant lapses in what enters your working memory," said Buitelaar. "So these connections are much harder to make."

The DeepStore team aims to lay the ground for better treatments for people with troubles in this area by expanding understanding of where and how the brain stores these memories. Until recently, conventional wisdom held that the working-memory system resided entirely in the brain's prefrontal cortex. Now it's known, albeit with limited detail, that many other parts of the brain are also involved.

"How storage of working memory is distributed in the brain still needs explaining," said Spitzer. "Getting to the bottom of this puzzle will take us an important step towards understanding the superpower of working memory."

The team believes the importance of working memory lies in its nimbleness—its ability to transform and reformat information.

"We now know it's highly adaptive and dynamic," said Spitzer. "For example, if I hold up a pen, you can store the information before your eyes in your working memory in myriad formats: as a photographic image, as an abstract concept linked to what you know to be the function of a pen or as an object that's being held at a certain angle. And your brain will be able to change the format according to the task the information is needed for."

The DeepStore team is using eye-tracking, functional brain scans and other non-invasive techniques for measuring brain activity and magnetic fields in people.

In a subsequent step, the researchers will look at data from electrodes implanted into the brains of non-human primates to decipher the neural underpinnings of working memory down to the single-cell level.

"By the end of our research, we hope to have a better understanding of the dynamics of working memory and how it provides us with just the right information at just the right time for whatever task is at hand," said Spitzer.

Knowing about and how

While some people struggle to retain transient information, others have trouble storing, preserving and retrieving data absorbed in the past.

Long-term memory is the focus of another research project.

Called MemUnited, it runs for two and a half years through May 2025 and is a collaboration between Ghent University in Belgium and Columbia University in the US.

The researchers aim to expand knowledge about the neural processes shared by the brain's two primary systems supporting long-term memory: the "declarative" and "procedural" ones.

Declarative memory processes allow the conscious recall of facts and past events—the "knowing about." This covers both general knowledge such as scientific concepts and personal experiences.

Procedural memory processes support the retention of skills, habits and "muscle memory." This is the "knowing how" function that includes things like riding a bike or preparing a mug of coffee.

"People typically use procedural knowledge to make a cup of coffee and automatically select the necessary actions in the right order," said Dr. Nina Dolfen, a Belgian psychologist who runs MemUnited.

Overlapping opportunities

Until recently, experts thought the procedural and declarative memory systems operated independently and involved different parts of the brain.

But [human brain scans](#) over the past decade have shown that some neural processes are shared, with both systems tapping into the hippocampus—a major part of the brain associated with memory.

Nonetheless, little is known about the overlap.

"If these two memory systems interact with each other, it's possible that an intact brain process can work like a scaffold, supporting learning in an area where there's a deficit," said Dolfen.

Examples exist where one long-term memory type is trained to compensate for the other after a brain injury—for instance, a stroke.

Dolfen referred to the example of the steps involved in making a cup of coffee to illustrate the possible impact on the brain of people who have endured a stroke.

"They may not remember the order of these steps while retaining the ability to execute the individual actions necessary to complete the task," she said.

Dolfen held out the eventual prospect of helping such people by tapping into their declarative memory through visual cues, with each step of the process represented by a different image.

Because the research is still at the fundamental rather than any applied stage, examining healthy volunteers is the best way to study the overlap between the declarative and procedural memory systems.

Dolfen is conducting memory tests on 35 young, healthy volunteers while monitoring their brain activity using functional magnetic resonance imaging, or fMRI. Ultimately, she hopes scientists will use her results to take advantage of the ways these two types of long-term memory overlap.

"If we can find creative ways to give people back their independence after an injury, that would be great," Dolfen said.

Recently, a research team reported a competition-integration mechanism of space-time encoding in individual hippocampal neurons. This discovery provides an essential neural basis for understanding episodic memory representation within spatiotemporal contexts.

The study was [published](#) in *Neuron* on September 5.

The hippocampus is a critical brain region for episodic memory, playing an important role in both spatial and temporal cognition. Previous studies have identified the presence of place cells and time cells in the hippocampus, which represent an organism's location in the environment and specific moments within a particular time interval. These cells may provide the neural basis for the spatial and temporal context signals in episodic memory.

However, the mechanisms underlying the interaction between space and time representation in the hippocampal memory system remain unclear.

To address this issue, the researchers designed various virtual reality and real-world navigation tasks and used in vivo single-photon microscopy to record and study the spatiotemporal representations of hippocampal CA1 neurons in mice under different movement speeds.

The study found that many neurons in the hippocampal CA1 region exhibit a shared representation of spatial and temporal information, whether in pure spatial navigation tasks (motion over a fixed distance without explicit temporal cues) or pure time perception tasks (motion over a fixed time period without spatial visual input). In other words, during the same task phase, these neurons functioned as both place cells and time cells.

Additionally, the temporal representations by CA1 cells captured the temporal regularity of the task, which may facilitate transfer learning. These results provide a unified processing mechanism for place and time cells and are consistent with theories that organize episodic memories based on a hippocampal spatiotemporal framework.

Furthermore, the researchers found that in certain place cells, the preferred spatial location was negatively correlated with elapsed time, meaning that the place field shifted backward over shorter time periods. Similarly, in some time cells, a negative correlation existed between the preferred time and the distance traveled. This competitive negative correlation significantly enhanced the informational content of the secondary dimension.

The team included Prof. Wang Cheng from the Shenzhen Institute of Advanced Technology (SIAT) of the Chinese Academy of Sciences, along with Assistant Prof. Chen Xiaojing from the Southern University of Science and Technology.

"Our findings elucidate the competitive-integration mechanism between spatial and temporal coding, consistent with the multiplexing of cognitive variables across different brain regions," said Prof. Wang. "This may better serve episodic memory by providing a more refined representation of spatiotemporal trajectories or contexts."

More information: Shijie Chen et al, Integration and competition between space and time in the hippocampus, *Neuron* (2024). DOI: [10.1016/j.neuron.2024.08.007](https://doi.org/10.1016/j.neuron.2024.08.007)

Provided by Chinese Academy of Sciences

How does the brain adapt to different levels of mental challenge? A new neuroimaging study reveals that when we engage in more complex cognitive tasks, our brain activity becomes not only richer in detail but also more streamlined. The findings suggest that the brain adjusts its patterns of activity to match the demands of the task, allowing for more efficient processing during mentally challenging activities.

The study, published in the *Proceedings of the National Academy of Sciences*, was driven by a desire to understand how the brain manages different cognitive demands. Previous research by the same team had revealed the brain's remarkable ability to reconstruct missing data from minimal measurements,

raising questions about why the brain can generate such detailed and efficient activity patterns with limited input.

“Several years ago, my co-author and graduate student at the time, Lucy Owen, and I came out with [a precursor to this study](#), where we found something very surprising,” explained study author Jeremy Manning, an associate professor of psychological and brain sciences at Dartmouth College and director of the [Contextual Dynamics Lab](#).

“At the time, we were working with neurosurgical patients who had electrodes implanted in their brains to monitor for seizure activity. A challenge with working with those recordings is that our brains contain roughly a hundred billion neurons, but we can only safely implant around a few hundred wires into someone’s brain. So there is a massive undersampling problem: for every measurement we take, we miss roughly a billion others! We wanted to understand how much of that ‘missing’ data we could reliably and accurately reconstruct using statistical ‘hacks.’”

“We were very surprised to find that just a few hundred measurements from an essentially random sampling of locations throughout someone’s brain could give us enough information to fill in an accurate guess about activity patterns throughout their entire brain, at millimeter-scale resolutions (roughly on par with the best fMRI available today), but at millisecond-scale sampling rates (roughly 1000 times faster than fMRI),” Manning said. “If human language was similarly efficient, I’d be able to tell you the details of every Wikipedia article just by speaking a dozen or so words.”

“In that initial study, we were primarily concerned with the ‘how’ and ‘what’ aspects of our approach: in other words, we reported how we built our model and generated guesses, how we validated the guesses, and the circumstances that affected accuracy, and so on. But it left us with a much deeper question that we weren’t able to answer back then: why is it possible to reconstruct what nearly our entire brain is doing at a given moment, using a comparatively miniscule number of measurements? That led us down a rabbit hole of additional questions about the fundamental properties of brain activity patterns. Our findings are reported in this new study.”

To answer these deeper questions about how the brain adjusts its activity to match cognitive demands, the researchers examined a dataset collected from

previous neuroimaging experiments. These experiments involved functional magnetic resonance imaging (fMRI) scans of participants as they listened to different audio recordings.

Some participants listened to a coherent, seven-minute story, while others listened to a scrambled version of the story, in which either the paragraphs or individual words were randomly ordered. A final group underwent a resting state scan with no auditory stimulus, meant to simulate a condition of minimal cognitive engagement.

The goal was to analyze how the brain's activity changed under these varying levels of cognitive demand. In a high-demand task—following a coherent story—the brain has to actively process and organize information to make sense of the narrative. In contrast, during the scrambled story conditions, the brain's task is less cognitively challenging because the information is less meaningful. The resting state condition provided a baseline measure of brain activity in the absence of any specific cognitive task.

The authors sought to investigate two properties of brain activity: informativeness and compressibility. The authors hypothesized that these properties might shift depending on the complexity of a task, allowing the brain to strike a balance between flexibility and efficiency.

To assess the informativeness and compressibility of brain activity, the researchers used advanced computational techniques. They measured informativeness by analyzing how much specific information about the task was reflected in participants' brain activity. Compressibility, on the other hand, was evaluated by examining how efficiently the brain's activity patterns could be represented using fewer components or data points. A highly compressible brain pattern is one in which fewer pieces of information are needed to reconstruct the full activity.

"In the world of machine learning, the ability to reconstitute a detailed pattern from its parts is called 'compression,'" Manning told PsyPost. "Highly compressible patterns can be accurately rebuilt from just a tiny sliver, like reconstructing the complete text of a novel from just a single word. Another related property is called 'informativeness.' This refers to how 'expressive' a sequence of patterns is—akin to the length of a novel."

The researchers uncovered two key findings. First, brain activity was more informative and compressible when participants engaged in the more demanding task of listening to a coherent story compared to the scrambled story or resting conditions. This suggests that during higher-level cognitive tasks, the brain produces detailed, information-rich activity that is also organized efficiently. In simpler tasks, or during rest, the brain's activity is less organized and contains less specific information.

Second, the study found that these brain patterns became more informative and compressible over time as participants continued to listen to the coherent story. As the narrative unfolded, the brain seemed to adapt by refining and optimizing its activity patterns. This pattern was less pronounced in the scrambled conditions, where the lack of a coherent structure in the story likely led to less mental engagement and, consequently, less organization in the brain's activity.

"Going into this study, we would have guessed that 'compression' and 'informativeness' would have changed in opposite directions," Manning said. "That would be analogous to either being able to reconstruct short novels from just a few words (perhaps under certain cognitive circumstances — representing high compressibility but low informativeness), or being able to reconstruct longer novels from more words (perhaps under different circumstances — representing low compressibility and high informativeness). Finding that compression and informativeness change in the same direction helped us to understand that these two aspects of how our brains respond can vary independently from each other."

The researchers also took a closer look at different brain networks to see if certain regions were more affected by task complexity than others. They found that higher-order brain networks, which are typically associated with complex functions like decision-making and memory, showed more pronounced changes in informativeness and compressibility than lower-order networks, which are primarily involved in basic sensory processing. This supports the idea that the brain's ability to adjust its activity is not uniform across all regions; instead, areas involved in more complex cognitive functions are especially responsive to task demands.

"We have known for a long time that our 'thoughts' come from patterns of electrical activity in our brains," Manning told PsyPost. "What we found is that our brains seem to change the 'language' that those patterns are expressed in

according to what we are doing. When we are highly engaged or thinking 'deeply' about what we are doing, our brains move into a mode where the activity patterns become both highly compressible and highly informative."

"In other words, our brains start representing what we are doing or thinking about in a very efficient way that is also incredibly robust to data corruption. That helped us understand why, under the right circumstances, it becomes possible to accurately guess what someone's entire brain is doing from just a few hundred measurements."

"When we stop being engaged, or when we think more 'shallowly' about what we are doing, our brains switch into a much less efficient mode, where the activity patterns become less structured, less informative, and more idiosyncratic," Manning continued. "We're not totally sure why this happens, but we go through some speculations in our paper."

The research provides valuable insights into the fundamental mechanisms of human cognition. But the study, like all research, has limitations. The study only examined a specific set of tasks and stimuli, which means that the results may not apply to all types of mental activities. Additionally, the researchers used one method of measuring brain activity—fMRI—which provides a detailed view of brain activity but is limited by its relatively slow sampling rate compared to other techniques.

"We looked at data from a little over 100 participants, using one set of experimental conditions, and using one method for measuring brain activity," Manning noted. "Although it is tempting to generalize to 'all humans and circumstances,' the true test of these findings, as with any study, will be in how well they replicate and generalize."

The researchers suggest that future studies could examine how the brain's ability to adjust informativeness and compressibility might apply to other cognitive processes, such as decision-making, problem-solving, or creativity. Understanding how these brain properties change in different contexts could offer new insights into the nature of cognition and how the brain adapts to a wide range of mental challenges.

Despite its limitations, the study provides a compelling look at how the brain organizes itself to meet the demands of complex tasks. The findings suggest that

the brain's ability to adapt is not just a matter of activating more areas or working harder, but rather involves fine-tuning its activity patterns to balance flexibility and efficiency.

In the long term, this line of research could help scientists better understand how the brain supports higher-level cognitive functions and what happens when these processes break down, such as in conditions like dementia or traumatic brain injury. By identifying the mechanisms that allow the brain to optimize its activity for different tasks, researchers may eventually develop new interventions or treatments to support cognitive health and recovery.

"We are deeply curious about understanding fundamental questions about how our brains work, and what makes us 'us.' This line of work is a tiny part of a much broader literature aimed at uncovering the neural basis of thought," Manning said. "My website is www.context-lab.com. It has links to all of my lab's publications, data, and software, along with some open courses that could be of interest to people who want to learn more about this stuff."

We often think our brains tick away time in perfect synchronization with the clocks on our walls and electronic devices. However, groundbreaking research published in the journal *Current Biology* provides evidence that our perception of time is not governed by an internal clock but by the number of experiences we have. This study found that changes in brain activity patterns, specifically in the anterior cingulate cortex, indicate that our brains track the passage of time based on the accumulation of experiences rather than a steady internal clock.

Time perception is a fundamental aspect of human experience, yet its underlying neural mechanisms remain largely mysterious. Scientists have long debated whether our brains use an internal clock or a different method to track time. The anterior cingulate cortex is known to support decision-making, memory, and behavioral flexibility, all of which require the integration of information over time.

"My work has long been centered on how networks of neurons change, either in response to stimuli, actions, outcomes, or contexts. For this project we were

actually interested in how reward expectancy changes when the likelihood of reward changes, and we found some interesting results that lead to a novel instantiation of reward prediction error ([Hyman et al., 2017 – Neuron](#)). A student and I started to examine how networks of neurons react during this task and we found a persistent change that occurred outside of changes in reward likelihood,” said study author James M. Hyman, an associate professor at the University of Nevada, Las Vegas.

“Time perception is one of the holy grail neuroscience topics. It’s one of those things we all experience changing on a daily basis in our lives, but the neural underpinnings of this psychological phenomenon are unknown. We didn’t set out to study time perception for this study, but the data revealed that networks changed slowly over the session. Each network from different animals changed in the same way and at the same rate. This led us to the conclusion that time processing was involved.”

The researchers conducted their study using five male Long-Evans rats, which were individually housed and food-restricted to 90 percent of their free-feeding weight. The rats were surgically implanted with micro-drives to record neural activity from the anterior cingulate cortex. After recovering from surgery, the rats performed a decision-free task in which they nose-poked into one of three ports to receive a reward. The ports had different reward probabilities, and the reward probabilities were reversed halfway through each session. This design ensured that the task was optimal for examining changes in neural activity without the influence of decision-making or varying reward rates.

During the experiments, the rats completed the trials at their own pace, leading to variations in how long it took each rat to complete all the trials. The researchers recorded the rats’ neural activity during the trials and analyzed the data using advanced techniques to identify patterns in the activity of neural ensembles (groups of neurons working together).

The study revealed that the anterior cingulate cortex ensembles exhibited a slow, drifting pattern of neural activity over the course of the task. This drift was strongly correlated with the number of trials the rats completed, not the actual time that had passed. This finding suggests that the anterior cingulate cortex tracks time by counting experiences rather than using an internal clock.

"With this data set we were able to ask whether time was being tracked by an internal clock or a counter, since animals completed trials at different paces," Hyman told PsyPost. "We found that the network change correlated with the number of trials, hence a counter not a clock. We could then go to the flip side and ask, ok, if it's a counter well then what would the time prediction be for different events and we found that fluctuated between animals. Animals that worked fast, their networks moved faster, animals that worked more slowly, had networks that changed more slowly."

"Since the mechanism we found in rat anterior cingulate cortex networks was so basic, we have every reason to believe similar changes are occurring in the primate brain," Hyman continued. The findings indicate that "mental time perception is affected by our activities and our experiences. This can be leveraged to control our perception of time. If something is unpleasant and you want to move past it, say a bad meal, then I'd suggest engaging in vigorous activity. Go for a walk, play a game, read a book, do something to move your neural networks 'forward' so to speak. This will make the bad meal further away."

"On the flip side, if something is really pleasant, then linger in that space. Don't change anything for a while. Don't start a new activity. Just sit and enjoy. This is not revolutionary advice, but now that we know that the neural networks that we think are responsible for our perception of time on behavioral scales (tens of minutes to hours) work in this way, the advice carries more weight."

Further analysis showed that this drift was consistent across different rats and sessions. The researchers used mathematical models to predict trial numbers and times based on neural activity and found that their predictions were highly accurate when based on the number of trials rather than clock time.

"A thing that surprised us was the consistency of these effects, animal to animal, brain to brain," Hyman said. "We were able to create pretty simple data models based on one animal's neural activity and predict what trial number a different animal was completing just based on its network activity. This is quite rare, since each brain is different and certainly the neurons we randomly encounter with our recordings are different each session. Since we utilized how networks changed and not what networks did, we were able to predict from brain to brain."

While this study provides compelling evidence that our brains track time based on experiences, it also has limitations. The task used in the study was decision-

free, meaning the rats did not choose which port to nose-poke. This passive aspect might have influenced the anterior cingulate cortex's neural dynamics differently than in a task involving active decision-making. Future research should explore how active tasks affect neural representations of time.

Another limitation is that the study was conducted on rats, and while their brain structures are similar to humans, there are differences. Additionally, the study focused on a relatively short period (tens of minutes). It remains to be seen how neural representations of time operate over longer durations, such as hours or days. Future studies should investigate whether the same mechanisms apply to these longer timescales.

Lastly, while the researchers identified a general trend of neural drift correlating with experiences, the specific contributions of individual neurons and how they combine to form ensemble dynamics require further exploration. Understanding these complex interactions will be crucial for fully grasping how our brains perceive time.

"A major caveat is that how these results relate to the psychological phenomenon of time passing is really speculative, since we couldn't ask the rats how much time they thought had passed," Hyman noted. "Even then, a rat's ability to accurately monitor time passing on a clock is gonna be different from our own, since we consistently see clocks all day and can calibrate our own internal understanding."

"This likely differs greatly individual to individual and also, task to task for those individuals. It's fascinating to think about how our modern world with the ubiquity of clocks is altering and helping us all refine our internal models of time passing. However, all the data we have still suggests that these internal models are based upon the accumulation of experiences or events."

The findings of this study have important implications for our understanding of time perception and its neural basis. By demonstrating that experiences, not an internal clock, drive our perception of time, this research challenges long-standing assumptions and opens new avenues for investigating temporal processing in the brain.

"Problems with temporal perception are often found in neurodegenerative and psychiatric disorders, and these effects can lead to serious handicaps in communication with others and cognitive errors that lead to mistakes/failures at

work," Hyman explained. "These things can lead to negative consequences in personal and professional life which can lead to bad outcomes, adding to depression and hopelessness. We hope to understand this cognitive process so that one day, we will be able to identify strategies, interventions, or treatments that can help people with such disorders. First, we must understand how the brain creates psychological phenomena before we can successfully alter such phenomena to help people."

The study, "[Temporal information in the anterior cingulate cortex relates to accumulated experiences](#)00688-2)," was authored by Ryan A. Wirt, Talha K. Soluoku, Ryan M. Ricci, Jeremy K. Seamans, and James M. Hyman.

Recalling memories is a straightforward task for humans – a simple act of closing our eyes often brings a flood of moments rushing back. However, beneath this seemingly effortless experience, there exist intricate [neural](#) processes.

Dartmouth College researchers have identified the complicated neurological systems that regulate how the human brain stores memories.

The findings revealed a "neural coding mechanism" in the brain that allows information to be transferred between perception and memory regions.

"We found that memory-related brain areas encode the world like a 'photographic negative' in space," said Adam Steel, the co-lead author, in an official release.

"And that 'negative' is part of the mechanics that move information in and out of memory, and between perceptual and memory systems," added Steel, who is a postdoctoral researcher in the Department of Psychological and Brain Sciences and fellow at the Neukom Institute for Computational Science at Dartmouth.

Examining brain activity

The researchers undertook a series of tests to learn more about how the brain encodes and recalls detailed memories.

The team used functional magnetic resonance imaging (fMRI) to capture brain

Via these experiments, the team pinpointed a "push-pull coding mechanism" that regulates the interaction between perceptual and memory areas.

"The results showed that when light hits the retina, visual areas of the brain respond by increasing their activity to represent the pattern of light. Memory areas of the brain also respond to visual stimulation, but, unlike visual areas, their neural activity decreases when processing the same visual pattern," explained the release.

The key results from the experiments

The authors were able to draw three key findings from their extensive observations.

Firstly, researchers revealed that brain memory systems retain a visual coding basis. Second, this visual code is displayed "upside-down" in memory systems, suggesting a distinct brain processing property.

"When you see something in your visual field, neurons in the visual cortex are driving while those in the memory system are quieted," said senior author Caroline Robertson, an assistant professor of psychological and brain sciences at Dartmouth.

Lastly, the link between perceptual and memory systems flips during memory recall, underscoring the complicated dynamics at work.

"If you close your eyes and remember that visual stimuli in the same space, you'll flip the relationship: your memory system will be driving, suppressing the neurons in perceptual regions," added Robertson, in the [press release](#).

The next step for the study team is to look at how this push-pull dynamic between perception and memory might help us comprehend cognitive processes in diseases like Alzheimer's.

The finding opens up new paths for studying the intricate interplay between perception and memory, perhaps leading to advances in neuroscience and therapeutic research.

The findings were published in the journal [Nature Neuroscience](#).

A study has revealed tantalizing clues about what may be happening in the brain when we daydream—a question that neuroscientists are still trying to understand.

While the latest research, published in the journal [Nature](#), was conducted on mice, the authors from Harvard Medical School (HMS) believe the findings could have implications for our understanding of the brain and its cognitive processes.

"We wanted to know how this daydreaming process occurred on a neurobiological level, and whether these moments of quiet reflection could be important for learning and [memory](#)," the study's lead author Nghia Nguyen, a PhD student in the Blavatnik Institute at HMS, said in a press release.

In the study, the researchers monitored the activity of neurons in the visual cortex—a brain region that processes visual information from the eyes—of mice during experiments in which the rodents were in a quiet waking state.

The scientists repeatedly showed the mice one of two images, consisting of a different checkerboard pattern featuring gray and dappled black-and-white squares. In between being shown the images, the rodents spent one minute looking at a gray screen.

The team found that when a mouse looked at the two images, neurons in their brain fired in specific patterns for each case. These patterns were sufficiently

distinctive that the scientists could discern which image the mouse had looked at from the neural activity.

Furthermore, when a mouse looked at the gray screen between images, the neurons sometimes fired in a similar, but not identical, pattern as when the mouse looked at the image. This was an indication that the mouse was thinking, or daydreaming, about the image, according to the researchers. These daydreams only occurred when the mice were in a relaxed state, the signs of which were calm behavior and small pupils.

Not surprisingly, the mice tended to daydream more about the most recent image they saw. And the researchers also found that they had more daydreams toward the beginning of the day compared to the end—by which point they had already seen each image numerous times.

But then the researchers made a finding that was unexpected. Throughout the day, and across days, the patterns of neuron activity observed when the mice looked at the images appeared to change. This phenomenon is known as "representational drift."

Over time, the patterns associated with each image became even more different from one another, until the point when each involved an almost entirely distinct set of neurons. Importantly, the pattern observed during a mouse's first few daydreams about an image could be used to predict how the brain's response to that same image would change over time.

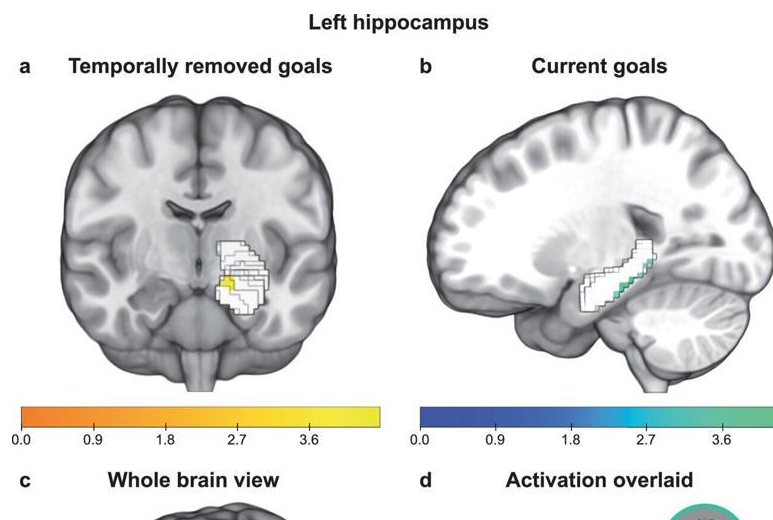
The findings of the study suggest that daydreams may be able to shape the brain's future response to what it sees, and that these moments during periods of quiet waking could play a role in brain plasticity—the brain's ability to "rewire" itself in response to new experiences. The authors note that these findings are preliminary and need to be explored further in future research.

"When you see two different images many times, it becomes important to discriminate between them. Our findings suggest that daydreaming may guide this process by steering the neural patterns associated with the two images away from each other," Nguyen said.

The latest findings align with a growing body of evidence in rodents and humans indicating that entering a state of quiet wakefulness after an experience can improve learning and memory.

While it remains to be seen whether or not the study's results will be applicable to humans, the researchers suggest that it may be important to make space for moments of quiet wakefulness that can result in daydreams.

"We feel pretty confident that if you never give yourself any awake downtime, you're not going to have as many of these daydream events, which may be important for brain plasticity," Mark Andermann, a senior author of the study at HMS, said in the press release.



Temporally removed goals activated the left anterior hippocampus and current goals activated the left posterior hippocampus. a Activation maps for the contrasts comparing the remote (distant future + near future + distant past + near past) > current are overlaid in yellow. b Activation maps for the contrasts comparing the current > remote are overlaid in green. c Activation for the temporally removed goals (yellow) and the current goals (green) shown concurrently on the brain. d The same goal, for instance fixing the space helmet, was anatomically dissociated along the longitudinal axis based on whether it was currently relevant, or relevant at a point removed in time. The left hippocampal region of interest (ROI) is displayed in white. Credit: Nature Communications (2024). DOI: 10.1038/s41467-024-48648-9 © Provided by Medical Xpress

H

ow does our brain distinguish between urgent and less urgent goals?

Researchers at the University of Geneva (UNIGE) and the Icahn School of Medicine in New York have explored how our brain remembers and adjusts the goals we set for ourselves on a daily basis.

Their study reveals differences in the way we process immediate and distant goals, at both behavioral and cerebral levels. These discoveries, [published](#) in the journal *Nature Communications*, could have significant implications for understanding psychiatric disorders, particularly depression, which can hamper the formulation of clear goals.

Throughout the day, we set ourselves goals to achieve: picking up the children from school in an hour, preparing dinner in three hours, making a doctor's appointment in five days or mowing the lawn in a week. These goals, both urgent and less urgent, are constantly redefined according to the events that occur throughout the day.

Researchers from the UNIGE and the Icahn School of Medicine at Mont Sinai Hospital in New York have studied how the brain memorizes and updates the goals to be achieved. More specifically, how the brain sorts out which goals require immediate attention and which do not.

Their study focused on a particular region of the brain, the hippocampus, because of its established role in episodic memory. This is responsible for encoding, consolidating and retrieving personally experienced information, integrating its emotional, spatial and temporal context.

An imaginary mission to Mars, in the time of an MRI scan

Neuroscientists asked 31 people to project themselves into an imaginary 4-year space mission to Mars, requiring them to achieve a series of objectives crucial to their survival (taking care of their space helmet, doing exercise, eating certain foods, etc.). The mission objectives varied according to when they had to be achieved, with different tasks for each of the four years of the journey.

As participants progressed through the mission, they were presented with the same objectives. They were then asked to indicate whether these were past, present or future goals.

As the participants moved forward in time, the relevance of these objectives changed: Objectives initially planned for the future became current needs, while current needs became past objectives.

In this way, participants had to manage several objectives at different distances in time and update their priorities as their mission progressed.

Prioritizing immediate objectives

The team observed the reaction times of each individual to determine whether the task was to be achieved in the present, the past or the future. "Goals to be achieved immediately are recognized more quickly than those to be achieved in the distant future. This different processing of stored information reveals the priority given to needs in the present over those in the distant future.

"It takes extra time to mentally travel back in time to retrieve past and future goals," explains Alison Montagrin, research and teaching fellow in the Department of Basic Neurosciences at the UNIGE Faculty of Medicine, former post-doctoral fellow at the Icahn School of Medicine, and first author of the study.

The scientists also investigated whether differences were also apparent at the cerebral level. Images obtained using very high-resolution MRI revealed that, when retrieving information about the present, the hippocampus is activated in its posterior region. On the other hand, when recalling past goals or goals to be achieved in the future, the anterior region is activated.

"These results are particularly interesting because previous studies have shown that when we call on our episodic memory or our spatial memory, the anterior region of the hippocampus is involved in retrieving general information, while the posterior part deals with details.

"It will therefore be interesting to explore whether—unlike immediate goals—projection into the future or recall of a past goal do not require specific details, but a general representation is sufficient," concludes the researcher.

This research shows that the time scale plays a crucial role in the way people set personal goals. This could have important implications for understanding psychiatric disorders such as depression. Indeed, people suffering from depression may present difficulties in forming specific goals and envisage more obstacles in reaching their objectives.

Investigating whether these people perceive the distance to their goals differently—which could make them pessimistic about their chances of success—could open up a therapeutic avenue.

More information: Alison Montagrin et al, The hippocampus dissociates present from past and future goals, *Nature Communications* (2024). DOI: [10.1038/s41467-024-48648-9](https://doi.org/10.1038/s41467-024-48648-9)

Provided by University of Geneva

The brain is constantly storing new experiences that it has to integrate into the jumble of existing memories. Surprisingly, it does not overwrite previous memory traces in the process.

The first day of school: entering the classroom for the first time, the excited feeling in your stomach and the joy of having a school bag—these are all typical examples of memories from our episodic memory. It stores unique personal episodes in a temporal and spatial order and links them to subjective experiences.

In a study at the Institut für Neuroinformatik at the Faculty of Computer Science of Ruhr University Bochum, Germany, a team led by Professor Laurenz Wiskott has developed a new computer model of episodic memory and thus made significant progress in understanding the hippocampus—the region of the brain that is crucial for the formation of new episodic memories.

[The work was published](#) on June 20, 2024 in the journal *PLOS ONE*.

Reliably storing sequences without destroying previous memories

Episodic memory is an important basis for our personal life story. It helps us to form our identity by storing and connecting past experiences and events in the right order.

"This happens through changes in the connections between the nerve cells in our brain," explains Laurenz Wiskott.

"A so-far unexplained phenomenon was how the human brain is able to make these changes without forgetting other memories—even though the experience is only seen exactly once and therefore cannot be slowly and carefully integrated into the circuit diagram of the nerve cells."

The Bochum researchers' innovative computer model makes it possible to recreate precisely this natural ability of the human brain: to reliably store sequences after a single presentation without destroying previous memories.

The model focuses on the principles of self-organization in the hippocampus and is based on the CRISP theory of Professor Sen Cheng, also a researcher at Ruhr University Bochum. The abbreviation stands for Content Representation, Intrinsic Sequences, and Pattern Completion.

In particular, the model redefines the function of the so-called CA3 region in the hippocampus. "Previously, it was assumed that episodic memories were stored directly in the CA3 network," says first author Dr. Jan Melchior.

"However, we now use the CA3 region only as a kind of anchor point for memory. Storing takes place in the regions that come before and after CA3."

A neural network like a well-organized library

To achieve this, the research team trained the CA3 region in their model with pre-information and thus, figuratively speaking, set up a well-organized library in CA3.

"When new books, i.e. new experiences, are added, the library does not have to be completely reorganized. Instead, the new books are added to the existing structure and linked to existing shelves and categories," continues Jan Melchior. This saves time and keeps the library well organized.

The CA3 region remains stable in the model and can work efficiently without the need to constantly adapt its internal structure. This makes the processing and storage of information faster and more reliable. Neural changes during the learning process occur exclusively in adjacent regions.

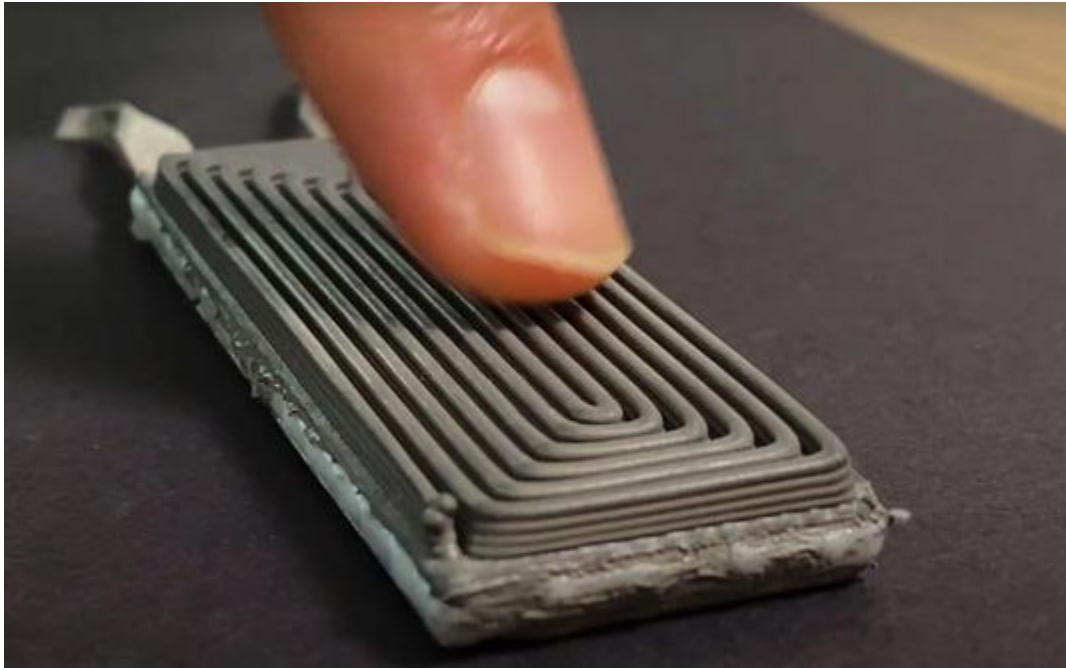
The results of the simulation convinced the researchers. "I still regard the robustness of the model as surprising," says Laurenz Wiskott.

"Even with incomplete or incorrect cues, a single presentation of a pattern sequence can be reliably stored, remembered and retrieved."

"The model works not only with artificially generated sequences, but also with handwritten numbers and natural images," adds Jan Melchior. "It can also improve itself without additional input by repeatedly replaying what it has learned."

More information: Jan Melchior et al, A neural network model for online one-shot storage of pattern sequences, *PLOS ONE* (2024). DOI: [10.1371/journal.pone.0304076](https://doi.org/10.1371/journal.pone.0304076)

Provided by Ruhr-Universitaet-Bochum



Credit: University of Washington

One of the drawbacks of fitness trackers and other wearable devices is that their batteries eventually run out of juice. But what if in the future, wearable technology could use body heat to power itself?

UW researchers have developed a flexible, durable electronic prototype that can harvest energy from body heat and turn it into electricity that can be used to power small electronics, such as batteries, sensors or LEDs. This device is also resilient—it still functions even after being pierced several times and then stretched 2,000 times.

The team detailed these prototypes in a paper [published](#) Aug. 30 in *Advanced Materials*.

"I had this vision a long time ago," said senior author Mohammad Malakooti, UW assistant professor of mechanical engineering. "When you put this device on your skin, it uses your body heat to directly power an LED. As soon as you put the device on, the LED lights up. This wasn't possible before."

Traditionally, devices that use heat to generate electricity are rigid and brittle, but Malakooti and team previously created one that is highly flexible and soft so that it can conform to the shape of someone's arm.

This device was designed from scratch. The researchers started with simulations to determine the best combination of materials and device structures and then created almost all the components in the lab.

It has three main layers. At the center are rigid thermoelectric semiconductors that do the work of converting heat to electricity. These semiconductors are surrounded by 3D-printed composites with low thermal conductivity, which enhances energy conversion and reduces the device's weight.

To provide stretchability, conductivity and electrical self-healing, the semiconductors are connected with printed liquid metal traces. Additionally, liquid metal droplets are embedded in the outer layers to improve heat transfer to the semiconductors and maintain flexibility because the metal remains liquid at room temperature. Everything except the semiconductors was designed and developed in Malakooti's lab.

In addition to wearables, these devices could be useful in other applications, Malakooti said. One idea involves using these devices with electronics that get hot.

"You can imagine sticking these onto warm electronics and using that excess heat to power small sensors," Malakooti said. "This could be especially helpful in data centers, where servers and computing equipment consume substantial electricity and generate heat, requiring even more electricity to keep them cool.

"Our devices can capture that heat and repurpose it to power temperature and humidity sensors. This approach is more sustainable because it creates a standalone system that monitors conditions while reducing overall energy consumption. Plus, there's no need to worry about maintenance, changing batteries or adding new wiring."

These devices also work in reverse, in that adding electricity allows them to heat or cool surfaces, which opens up another avenue for applications.

"We're hoping someday to add this technology to virtual reality systems and other wearable accessories to create hot and cold sensations on the skin or enhance overall comfort," Malakooti said. "But we're not there yet. For now, we're starting with wearables that are efficient, durable and provide temperature feedback."

More information: Youngshang Han et al, 3D Soft Architectures for Stretchable Thermoelectric Wearables with Electrical Self-Healing and Damage Tolerance, *Advanced Materials* (2024). DOI: [10.1002/adma.202407073](https://doi.org/10.1002/adma.202407073)

Provided by University of Washington

How can the brain continue to learn without overloading our memory?

Article author: Cédric DEPOND

Source: [Science](#)

A recent study from Cornell University reveals that sleep not only consolidates memory but also resets neurons, allowing the brain to keep learning without depleting its resources. This discovery could have major implications for treating neurological disorders such as Alzheimer's disease or post-traumatic stress disorder.

When a person learns or experiences new things, neurons in the hippocampus, a key brain region for memory, become active. During sleep, these neurons replay the activity patterns observed during the day, a process essential for memory consolidation, with memories then stored in the cortex. However, scientists have questioned how the brain can continue acquiring new information throughout life without exhausting its neurons.

The study, published in *Science*, shows that at certain moments during deep sleep, specific regions of the hippocampus "shut down," allowing neurons to reset. Azahara Oliva, assistant professor of neurobiology and lead author of the study, explains: "This mechanism might allow the brain to reuse the same neurons for new learning the next day."

The hippocampus is divided into three main regions: CA1, CA2, and CA3. The CA1 and CA3 regions, well-studied, are involved in encoding time-and-space-related memories. In contrast, the function of CA2 was less understood until now. This research

demonstrated that CA2 is essential in causing the silencing of other hippocampal regions, thus facilitating memory "reset" during sleep.

Researchers implanted electrodes in the hippocampus of mice to record neural activity during learning and sleep. They observed that neurons in the CA1 and CA3 regions replay neural patterns developed during the day before being silenced by the influence of CA2. This suggests the brain has parallel circuits regulated by two types of neurons: pyramidal neurons, crucial for learning, and interneurons, which ensure memory resetting.

This discovery is pivotal in understanding why sleep is essential in all animals: it not only serves to consolidate memories but also to reset the brain for continued functionality during waking hours. Researchers hope this knowledge can be used to enhance memory and treat related disorders, like Alzheimer's, or to erase traumatic memories.