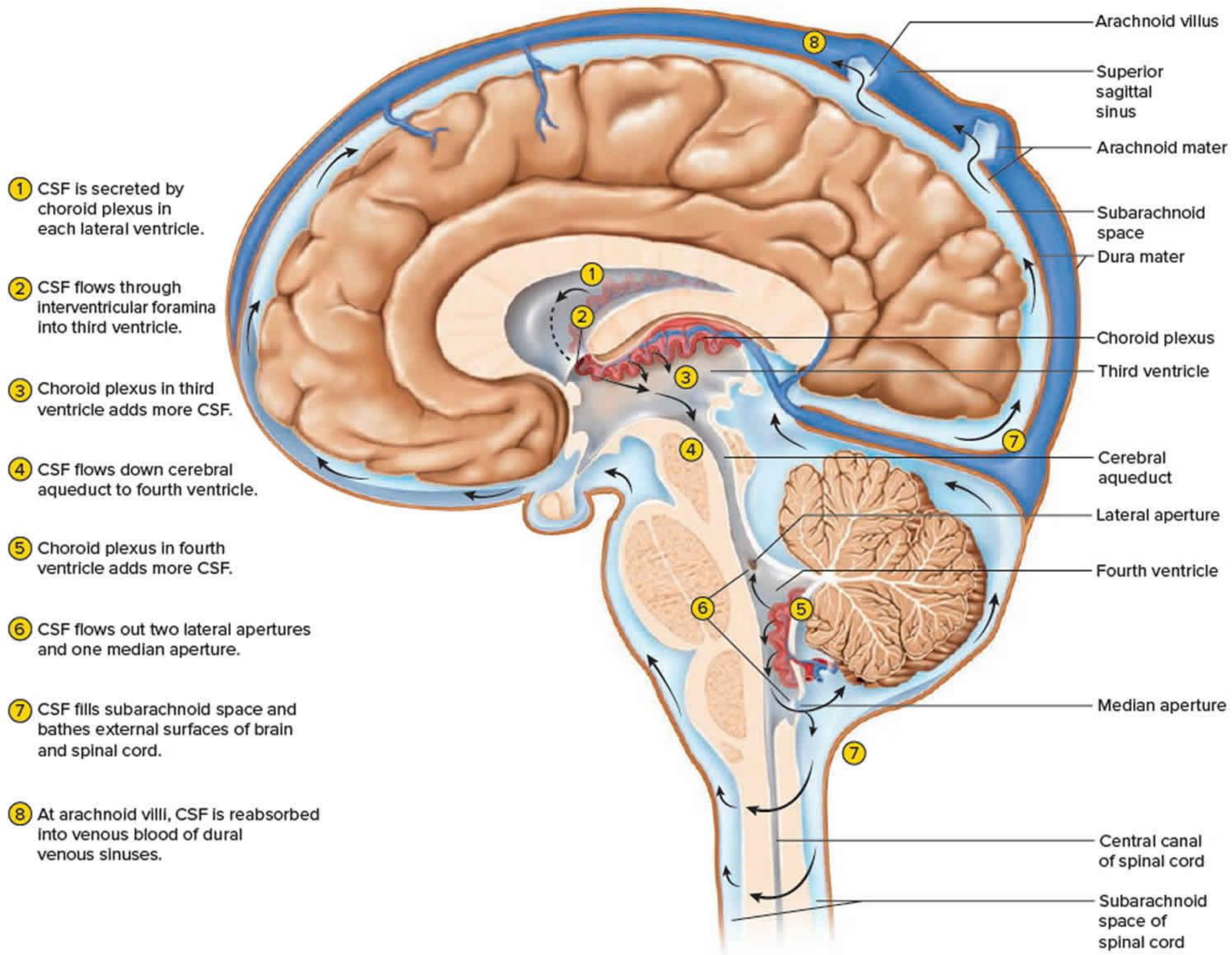
BRAIN INTRACRANIAL VOL 4



Cerebrospinal fluid formation, absorption and circulation around and within the brain

Hippocampus uses dual pathways for memory storage

Overview and motivation. Credit: Nature Communications (2024). DOI: 10.1038/s41467-024-44877-0© Provided by Medical Xpress

The mechanism by which our brains record events in stereo—with one channel recording details and another recording general impressions—has been elicited by two RIKEN neuroscientists.

Our memories have two aspects to them: they allow us to recall specific episodes from the past, but they also enable us to draw general concepts from them. For example, we can recall the specifics about a recent visit to see a friend, but we can also extract generalizations about their appearance and personality.

The brain region known as the hippocampus is responsible for both abilities, but just how it manages to do this has been unclear.

Louis Kang of the RIKEN Center for Brain Science (CBS) has long been interested in how memories are stored in the hippocampus. "The hippocampus has always fascinated me," he says. "I think the origin of memories is quite mysterious, even now."

Interestingly, the hippocampus receives two inputs: one in which experiences arrive directly from the brain region upstream from it; and another where it makes a detour through another brain region, where it undergoes processing.

Kang and Taro Toyoizumi, also of CBS, wondered whether the direct pathway that signals information with dense neural activity represents memories with general impressions, while the other one that does so with sparse activity represents all their details.

To test this conjecture, they used techniques from statistical physics (both researchers share a background in physics) to create a mathematical model of neural circuits in the hippocampus. The pair then tested the model using images of three items of clothing: sneakers, trousers and coats. They found that the first pathway stored the details of each image, while the second one generated general conceptual images of each kind of clothing.

Their work has been published in *Nature Communications* and *Physical Review E*.

At this stage, the model provided a plausible description of what could be happening in the hippocampus, but more evidence was needed to support it. "Our model proposed one possible explanation for how the brain remembers both example-like and concept-like memories," says Kang. "But other explanations were also possible."

To obtain further confirmation, the researchers tested their model using experimental recordings of the neurons in the mouse hippocampus that were freely available online. They noticed a signature generated by the model was also present in the recordings. "This supports the possibility that the brain behaves according to our model," says Toyoizumi.

Finally, the two researchers applied the same approach to machine learning, so that neural networks represent information in both example-like and concept-like forms. This resulted in improved performance when distinguishing between similar images and identifying their common features.

"This work shows how biological intelligence can inspire better algorithms for artificial intelligence," notes Kang.

More information: Louis Kang et al, Distinguishing examples while building concepts in hippocampal and artificial networks, *Nature Communications* (2024). DOI: 10.1038/s41467-024-44877-0

Louis Kang et al, Hopfield-like network with complementary encodings of memories, *Physical Review E* (2023). DOI: 10.1103/PhysRevE.108.054410

The Gold Standard For Measuring Brain Activity Has Been Around For 100 Years

— CHRISTOPH BURGSTEDT/SCIENCE PHOTO LIBRARY/Science Photo Library/Getty Images© Provided by Inverse

Jena, Germany, 1924: Working in near-isolation and with painstaking tediousness, the psychiatrist Hans Berger observes rhythmic electrical activity from the scalp of human subjects. He is convinced the activity arises from within the brain and coins the term "electroencephalogram."

It is 10 years before the scientific community accepts Berger's work, birthing the field of electroencephalography, or EEG for short.

Today, the electroencephalogram – also abbreviated as EEG – is widely known as a medical test measuring brain electrical activity that's used on patients who have or are suspected to have neurological disorders. The EEG provides a window into the living brain, with a continuous electrical readout of what is happening inside our heads. The procedure may be short, often just a 30-minute recording. But for patients monitored for diagnosis or treatment of brain disease, it can be continued for much longer – days or even weeks.

As a neurologist specializing in epilepsy, I use EEG on a daily basis. Our team at the University of Florida interprets thousands of EEGs a year in neurological patients. I also run a research lab where our goal is to understand the basic structure of the EEG in health and disease.

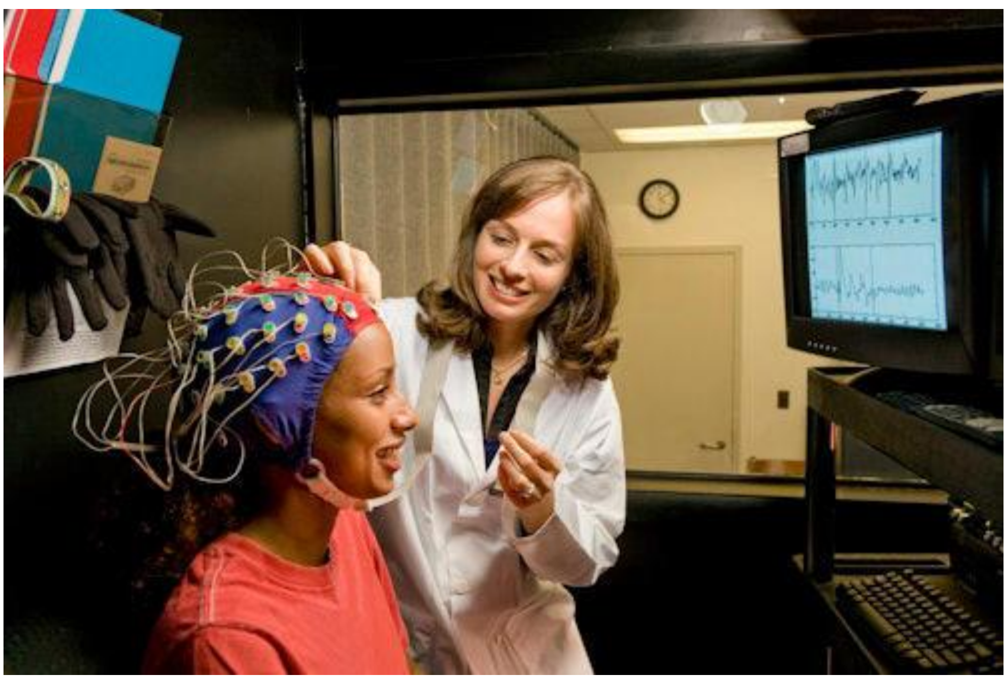
A history of unexpected twists

The story of EEG is colorful and littered with fables. Berger's interest in brain electricity was not to combat disease, though that was his day job as a physician, but to find a biological basis for his belief in telepathy. He wondered whether the brain waves of EEG could convey thoughts through space, allowing people to read each other's minds. He was unsuccessful in his mission, but the field he founded nonetheless took off.

By the mid-1930s, researchers had observed the striking differences between the awake and asleep EEG. The EEGs of patients with brain disease turned up a variety of unprecedented observations.

And then came a defining moment for modern medicine. In December 1934, a group of Boston physicians observed the rhythmic EEG spike-wave appearance of seizures in patients with "petit mal" epilepsy. Petit mal is an anachronistic term for a type of epilepsy where a patient's flow of thought, speech, or action momentarily freezes during seizures. For the first time, the symptoms and behavior of patients during seizures were correlated to a brain signal occurring in lockstep.

EEG quickly evolved from a scientific curiosity to a mainstream clinical tool. The first clinical EEG laboratory was set up at Massachusetts General Hospital in 1937. The practice grew in the ensuing decades into the specialized services that institutions like ours have offered since the 1970s.



The Gold Standard For Measuring Brain Activity Has Been Around For 100 Years© Provided by Inverse

The EEG explained

So what, exactly, is the EEG?

Imagine taking two small metallic discs connected by a conducting wire. Place one disc on the scalp and connect the other to a neutral reference, such as the ear. Watch a tiny alternating current flow in the wire, proportional to the electrical activity sensed by the conducting contact. This activity is the EEG, the electrical milieu that bathes brain tissue.

In turn, the EEG arises from the excitable nature of nerve cells or neurons. When neurons fire, action potentials – brief, high-voltage spikes traveling outward from their cell bodies – set up local electrical activity in other neurons, causing current to flow within and outside them.

These local current flows may cause the targeted neurons to fire in turn and set up yet more current flows. Thus, the system sustains itself. The average overall activity is a mix of many different frequencies, with the five main ones called delta, theta, alpha, beta, and gamma waves.

If the EEG were just random up-and-down drift – "the bloodless dance of action potentials," commented a skeptical early 20th century neurologist – it would be much less interesting. The remarkable fact is that EEG tends to spontaneously organize into patterns in time and space.

The spike-wave pattern of petit mal, referenced earlier, is a classic example, but scores of others are now known. Clinical EEG practice is just recognizing characteristic EEG patterns and correlating them to specific disease states.

Fluctuating neurons

Beyond the clinic, an unsettling scientific question emerges. Simply put, how do electrical patterns arise in the brain? How do the billions of neurons and their trillions of local current flows fluctuate in just the right ways to create a globally ordered structure?

Our research group has been interested in the fundamental question of pattern formation in EEG. It turns out that activity in the brain is naturally repetitive – that is, oscillatory. This is due to the way neurons are connected and the fact that they interact by excitation and inhibition to produce push-pull effects.

Considering local oscillations as fundamental building blocks, we showed that the EEG over the entire brain could be built up from such elementary blocks. More interestingly, the differing frequencies could be made to coalesce or synchronize into a common rhythm. We recognized that synchronization of this type underlies some seizurelike patterns observed in patients.

EEG, AI, and the mind

Pattern formation in nature is deeply fascinating. How does a leopard get its spots? How does the audience at a concert spontaneously settle into a rhythmic applause? Many such questions trace their origin to a classic paper on biological patterns published in 1952. Its author was Alan Turing, better known as the father of computer science and early advocate of artificial intelligence, or AI.

The hardware underlying the majority of today's AI systems are neural networks. Neural networks were introduced in 1943 by Warren McCulloch, a physician and electroencephalographer. Like Berger, McCulloch's interest in EEG extended beyond brain disease. He wondered where in the brain's neurons and EEG lay the capacity to think. He conceived the idea of grouping artificial neuronlike computing units into networks, analogous to how real neurons in the brain are interconnected.

Together with Walter Pitts, he proved that such neural networks could function as a general-purpose computer. The seminal McCulloch-Pitts ideas were refined over the ensuing decades and reside in the "deep learning" neural networks of today's AI.

Deep learning AI has infiltrated all areas of biomedicine, including neurology. For example, AI systems can successfully interpret brain scans. AI methods have also been used to analyze EEG. Can AI systems be trained to deduce thoughts from the EEG? Can AI approach Berger's quest for telepathy? Incredibly, recent deep-learning AI research has shown that some aspects of mental activity may be decoded from EEG.

In 2024, EEG turns 100. What windows will it open into the brain and mind in the future? Doubtless, clinical applications will grow. Surely, brain pattern generation will be better understood. Perhaps EEG will glimpse the content of the mind. And for neurologists like me surveying the AI revolution, there's the quiet pride that EEG was really at the start of it all.

Tentacle-like brain probes offer high-precision, long-term neural recording

A bundle of extremely fine electrode fibres in the brain (microscope image). (Image: Yasar TB et al. Nature Communications 2024, modified)© PsyPost

Researchers at ETH Zurich have developed ultra-flexible brain probes that can record brain activity over long periods without damaging the surrounding tissue. Published in *Nature Communications*, the study demonstrates how these innovative electrodes could advance treatments for neurological and psychiatric disorders by offering detailed, long-term monitoring of brain activity.

"Our electrodes are so fine that they can be threaded past the long processes that extend from the nerve cells in the brain," said Mehmet Fatih Yanik, Professor of Neurotechnology at ETH Zurich, who led the research. "They are only around as thick as the nerve-cell processes themselves."

The researchers conducted this study to overcome the limitations of existing brain-monitoring technologies. Traditional electrodes, used in devices like neurostimulators or "brain pacemakers," are often rigid and too wide, posing risks of tissue damage when implanted. These devices are already used to treat conditions such as Parkinson's disease, but their potential is limited by their inability to provide detailed and safe long-term recordings.

Yanik's team sought to develop an alternative that could collect high-quality brain signals over extended periods, offering new opportunities for diagnosing and treating neurological conditions. "Our goal was to create electrodes that could record brain activity with great precision, but without causing inflammation or damage, as current technologies often do," Yanik explained.

To achieve this, the team designed electrodes made from ultra-thin, flexible gold fibers encased in a polymer. The fibers, which are only as thick as the processes of nerve cells themselves, are much smaller than current electrode technologies. This delicate design minimizes the risk of damaging the brain when inserted. To further reduce any potential harm, the researchers developed a method to slowly insert the probes into the brain, allowing the fibers to weave through the tissue gently.

The researchers tested the new probes in rats, inserting bundles of 64 fibers into various brain regions. These fibers were connected to a small recording device mounted on each rat's head, allowing the animals to move freely while their brain activity was monitored. The electrodes were then able to record signals from the same cells in the rats' brains for up to 10 months without any noticeable damage to the brain tissue.

One of the most important findings from the study was that these new probes are biocompatible, meaning they do not interfere with normal brain function. In fact, the electrodes were able to record high-quality signals due to their proximity to nerve cells.

Over the 10-month experiment, the probes maintained their performance, providing consistent and detailed recordings from the same brain cells. This longevity is a major improvement over current technologies, which often see a decline in signal quality over time due to tissue damage or immune responses.

The flexibility of the electrodes also allowed the researchers to monitor different regions of the brain simultaneously. This is particularly important for understanding how different brain areas work together. In their experiments, the researchers tracked and analyzed nerve cell activity in several regions of the rats' brains. They found that nerve cells in different regions were often "co-activated," meaning they fired together. This large-scale, synchronized activity is believed to be essential for processing complex information and forming memories.

"The technology is of high interest for basic research that investigates these functions and their impairments in neurological and psychiatric disorders," Yanik said.

Despite the promising results, the study does have limitations. Most notably, the testing has so far been limited to animals, and human trials are still in the planning stages. While the electrodes appear to be safe for long-term use in rats, it remains to be seen how they will perform in humans over extended periods. The long-term effects of the implants will need to be thoroughly evaluated, particularly in terms of whether they can continue to function without causing damage to human brain tissue.

Additionally, while the flexibility of the probes offers many advantages, it also poses challenges. For example, the fibers are so thin that inserting them into deeper brain regions in larger animals or humans may require even more advanced surgical techniques. The team is already working on refining the technology to address these challenges and improve the overall ease of use.

Looking ahead, the researchers are planning to test the electrodes in humans. They have partnered with University College London to use the new probes in epilepsy patients who do not respond to drug treatments. In these cases, neurosurgeons often remove a small section of the brain where seizures originate. The team hopes their probes will help pinpoint the exact location of the problematic brain tissue, improving the precision of these surgeries.

The potential applications of these probes extend beyond epilepsy. The electrodes could also be used to treat psychiatric disorders such as depression, schizophrenia, or obsessive-compulsive disorder. Many of these conditions are associated with abnormal brain activity in specific regions. By detecting these abnormal signals early, it may be possible to correct them using electrical stimulation.

“This could aid the development of more effective therapies for people with neurological and psychiatric disorders,” said Yanik.

The study, “Months-long tracking of neuronal ensembles spanning multiple brain areas with Ultra-Flexible Tentacle Electrodes,” was authored by Tansel Baran Yasar, Peter Gombkoto, Alexei L. Vyssotski, Angeliki D. Vavladeli, Christopher M. Lewis, Bifeng Wu, Linus Meienberg, Valter Lundegardh, Fritjof Helmchen, Wolfger von der Behrens , and Mehmet Fatih Yanik.

Human Brains Have Gotten Astonishingly Bigger Over the Last 75 Years

The incredible study sheds a light on the resilience of modern minds.© Ignatiev - Getty Images

- 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.

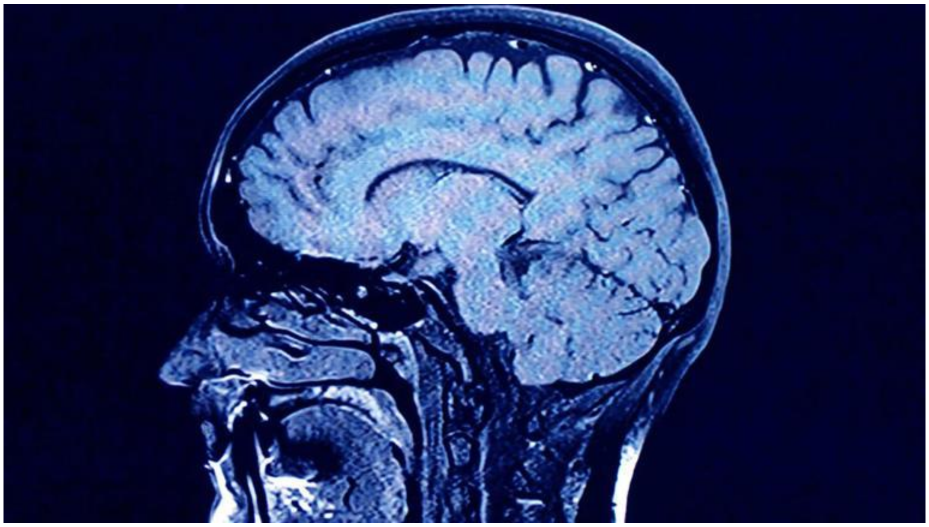
As mentioned, the average volume of the brain was found to have increased 6.6 percent, but the cortical surface area showed an overall 15 percent increase in volume when comparing participants from the 1970s to those in the 1930s. In addition, structures of the brain—such as white matter, gray matter, 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.

Why brain aging can vary dramatically between people



Researchers find that both genetic influences and lifestyle factors can affect an aging brain.© Roxana Wegner/Moment RF/Getty Images/File

Researchers are uncovering deeper insights into how the human brain ages and what factors may be tied to healthier cognitive aging, including exercising, avoiding tobacco, speaking a second language or even playing a musical instrument.

Some aspects of cognitive abilities in older age may be connected to test scores around age 11, according to a review paper published Thursday in the journal Genomic Psychiatry from Genomic Press New York.

The paper, based on data from the Lothian Birth Cohorts studies in Scotland, suggests that about half of the variabilities in people's cognition at older ages – why some people may have greater cognitive decline than others – may already have been present in their childhoods.

Yet some adult lifestyle factors still appeared to be linked with improved cognitive performance and slower aging of the brain.

“We have found that things like keeping physically and mentally active and engaged, having few ‘vascular’ risk factors (such as high blood pressure, cholesterol, smoking, BMI), speaking a second language, playing musical instruments, and having a younger-looking brain and many more show detectable-but-small associations,” Simon Cox, an author of the new paper and director of the Lothian Birth Cohort Studies at the University of Edinburgh, said in an email.

“We came up with the idea that ‘Marginal Gains, Not Magic Bullet’ is a good way to think about a recipe for better cognitive ageing: rather than finding that one single thing has a huge risk, we see lots and lots of (often partly-overlapping) factors that each probably contributes a little bit to your risk for cognitive ageing,” Cox said.

He added that such lifestyle factors – when they are considered all together – can add up to explaining “about 20%” of the differences seen in cognitive declines across the ages of 70 to 82.

The Lothian Birth Cohorts involve data from two studies of older adults: a group of Scottish adults born in 1921 and another group born in 1936. They all took a validated cognitive test at age 11 and were then tested in their 70s, 80s and 90s for cognitive functions and fitness, among other factors.

“We first took MRI scans of the participants when they were 73 years old. One of the most striking things about the study for me is how wide the differences are between their scans,” Cox wrote.

“Even though they were all the same age, some brains looked perfectly healthy (and wouldn’t be out of place amongst scans of 30 or 40 year olds),” he said. “Whereas others showed lots of shrinkage and damage to the white matter connections, along with other features that are related to cognitive ageing and dementia.”

White matter is the tissue that forms connections between brain cells and the rest of the nervous system, helping these regions communicate with each other through nerve signals. Having decreased or damaged white matter can slow the brain’s ability to process information.

Overall, “it shows us that brain ageing at age 73 is not an inevitability, while also strongly motivating us to research what we can do to emulate those lucky few who arrive at that age with such pristine brains,” Cox said.

Older adults whose memory seems as sharp as that of people 20 to 30 years younger have been referred to as cognitive super agers.

“Not all of the aspects of brain ageing happen together in the same people,” Cox said. “We are now looking into whether different constellations of brain ageing features are driven by particular subsets of risk factors.”

As a researcher of the aging brain, Dr. Richard Isaacson said, the new paper spoke to him.

“It was a really practical, narrative overview of the ‘nuts and bolts’ about why this type of research is so hard, and several best practices to retain as much value as you can when you start a long-term study like this,” said Isaacson, director of research at the Institute for Neurodegenerative Diseases in Florida, who was not involved in the paper.

There is a robust body of research on key differences in lifestyle that may contribute to differences in an aging brain. For instance, poor sleep is a key risk factor for cognitive decline, and mental health issues such as depression are known risk factors for developing dementia.

Getting regular exercise by walking or cycling just three times a week may improve thinking skills, according to a 2018 study. Adding a heart-healthy diet to your routine also can help slow brain aging and reduce dementia risk. And a 2020 study suggests that daily meditation could slow brain aging.

Experts developed a tool named the Brain Care Score and a study published last year showed that it may help assess a person’s risk of developing dementia or having a stroke as they age.

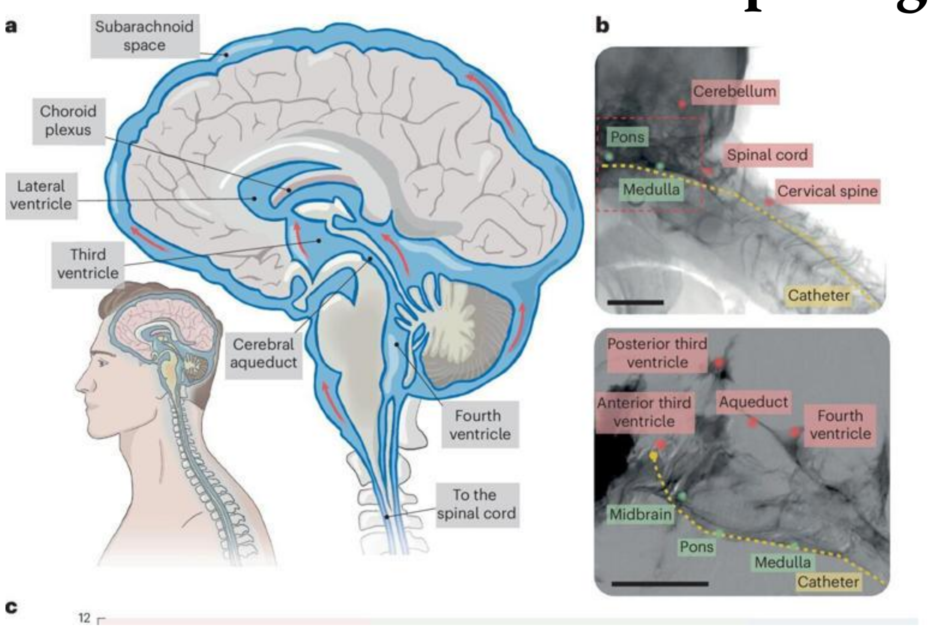
The 21-point score refers to how a person fares on 12 health-related factors concerning physical, lifestyle and social-emotional components of health, according to the study, published in the journal Frontiers in Neurology. The researchers found that participants with a higher score had a lower risk of dementia or stroke later in life.

Those 12 factors are blood pressure, blood sugar, cholesterol, body mass index, nutrition, alcohol consumption, smoking, aerobic activities, sleep, stress, social relationships and finding meaning or purpose in life.

For anyone hoping to improve the health of their aging brain, "seeing your doctor at least every year or twice a year" to talk about your overall physical health, vascular health and chronic diseases is important, Isaacson said.

"Those things may not exactly cause Alzheimer's, but it can fast forward cognitive aging and fast forward cognitive decline. So seeing your primary care doctor and getting your blood pressure taken – everyone needs to know their numbers. What is your blood pressure? What is your fasting blood sugar? What are your cholesterol numbers?" he said. "Another important thing is to track bone health. I think a lot of people are unaware that bone health, muscle strength and grip strength are things that are absolutely imperative and predict brain health outcomes over time."

Minimally invasive neural interface allows brain access without skull opening



Endocisternal neural interface in human and sheep models. Credit: Nature Biomedical Engineering (2024). DOI: 10.1038/s41551-024-01281-9

A team of researchers led by Rice University's Jacob Robinson and the University of Texas Medical Branch's Peter Kan has developed a technique for diagnosing, managing and treating neurological disorders with minimal surgical risks. The team's findings were published in *Nature Biomedical Engineering*.

While traditional approaches for interfacing with the nervous system often require creating a hole in the skull to interface with the brain, the researchers have developed an innovative method known as endocisternal interfaces (ECI), allowing for electrical recording and stimulation of neural structures, including the brain and spinal cord, through cerebral spinal fluid (CSF).

"Using ECI, we can access multiple brain and spinal cord structures simultaneously without ever opening up the skull, reducing the risk of complications associated with traditional surgical techniques," said Robinson, professor of electrical and computer engineering and bioengineering.

ECI uses CSF, which surrounds the nervous system, as a pathway to deliver targeted devices. By performing a simple lumbar puncture in the lower back, researchers can navigate a flexible catheter to access the brain and spinal cord.

Using miniature magnetoelectric-powered bioelectronics, the entire wireless system can be deployed through a small percutaneous procedure. The flexible catheter electrodes can be navigated freely from the spinal subarachnoid space to the brain ventricles.

"This is the first reported technique that enables a neural interface to simultaneously access the brain and spinal cord through a simple and minimally invasive lumbar puncture," said Kan, professor and the Robert L. Moody Sr. Chair of Neurosurgery at UTMB. "It introduces new possibilities for therapies in stroke rehabilitation, epilepsy monitoring and other neurological applications."

To test the hypothesis, the research team characterized the endocisternal space and measured the width of the subarachnoid, or fluid-filled space, in human patients using magnetic resonance imaging. The researchers then conducted experiments in large animal models, specifically sheep, to validate the feasibility of the new neural interface.

Their experiments showed that the catheter electrodes could be successfully delivered and guided into the ventricular spaces and brain surface for electrical stimulation. By using the magnetoelectric implant, the researchers were able to record electrophysiologic signals such as muscle activation and spinal cord potentials.

Preliminary safety results showed that the ECI remained functional with minimal damage up to 30 days after the electronic device was implanted chronically into the brain.

Moreover, the study revealed that unlike endovascular neural interfaces that require antithrombotic medication and are limited by the small size and location of blood vessels, ECI offers broader access to neural targets without the medication.

"This technology creates a new paradigm for minimally invasive neural interfaces and could lower the risk of implantable neurotechnologies, enabling access to wider patient populations," said Josh Chen, Rice alumnus and lead author of the study.

More information: Joshua C. Chen et al, Endocisternal interfaces for minimally invasive neural stimulation and recording of the brain and spinal cord, *Nature Biomedical Engineering* (2024). DOI: 10.1038/s41551-024-01281-9

Provided by Rice University

Neuroscientists find that just thinking about a location activates mental maps in the brain

Credit: CC0 Public Domain© Provided by Medical Xpress

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. www.nature.com/articles/s41586-024-07557-z

This story is republished courtesy of MIT News (web.mit.edu/newsoffice/), a popular site that covers news about MIT research, innovation and teaching.

Provided by Massachusetts Institute of Technology

Researchers map the spatio-temporal human brain dynamics of a visual image being recognized

A team of MIT researchers found highly memorable images have stronger and sustained responses in ventro-occipital brain cortices, peaking at around 300ms. Conceptually similar but easily forgettable images quickly fade away. Credit: Alex Shipps/MIT CSAIL© Provided by Medical Xpress

For nearly a decade, a team of MIT Computer Science and Artificial Intelligence Laboratory (CSAIL) researchers have been seeking to uncover why certain images persist in people's minds, while many others fade. To do this, they set out to map the spatio-temporal brain dynamics involved in recognizing a visual image.

And now for the first time, scientists harnessed the combined strengths of magnetoencephalography (MEG), which captures the timing of brain activity, and functional magnetic resonance imaging (fMRI), which identifies active brain regions, to precisely determine when and where the brain processes a memorable image.

Their open-access study, published this month in *PLOS Biology*, used 78 pairs of images matched for the same concept but differing in their memorability scores—one was highly memorable and the other was easy to forget.

These images were shown to 15 subjects, with scenes of skateboarding, animals in various environments, everyday objects like cups and chairs, natural landscapes like forests and beaches, urban scenes of streets and buildings, and faces displaying different expressions.

What the researchers found was that a more distributed network of brain regions than previously thought are actively involved in the encoding and retention processes that underpin memorability.

"People tend to remember some images better than others, even when they are conceptually similar, like different scenes of a person skateboarding," says Benjamin Lahner, an MIT Ph.D. student in electrical engineering and computer science, CSAIL affiliate, and first author of the study.

"We've identified a brain signature of visual memorability that emerges around 300 milliseconds after seeing an image, involving areas across the ventral occipital cortex and temporal cortex, which processes information like color perception and object recognition. This signature indicates that highly memorable images prompt stronger and more sustained brain responses, especially in regions like the early visual cortex, which we previously underestimated in memory processing."

While highly memorable images maintain a higher and more sustained response for about half a second, the response to less memorable images quickly diminishes. This insight, Lahner elaborated, could redefine our understanding of how memories form and persist. The team envisions this research holding potential for future clinical applications, particularly in early diagnosis and treatment of memory-related disorders.

The MEG/fMRI fusion method, developed in the lab of CSAIL Senior Research Scientist Aude Oliva, adeptly captures the brain's spatial and temporal dynamics, overcoming the traditional constraints of either spatial or temporal specificity.

The fusion method had a little help from its machine-learning friend, to better examine and compare the brain's activity when looking at various images. They created a "representational matrix," which is like a detailed chart, showing how similar neural responses are in various brain regions. This chart helped them identify the patterns of where and when the brain processes what we see.

Picking the conceptually similar image pairs with high and low memorability scores was the crucial ingredient to unlocking these insights into memorability. Lahner explained the process of aggregating behavioral data to assign memorability scores to images, where they curated a diverse set of high- and low-memorability images with balanced representation across different visual categories.

Despite strides made, the team notes a few limitations. While this work can identify brain regions showing significant memorability effects, it cannot elucidate the regions' function in how it is contributing to better encoding/retrieval from memory.

"Understanding the neural underpinnings of memorability opens up exciting avenues for clinical advancements, particularly in diagnosing and treating memory-related disorders early on," says Oliva. "The specific brain signatures we've identified for memorability could lead to early biomarkers for Alzheimer's disease and other dementias.

"This research paves the way for novel intervention strategies that are finely tuned to the individual's neural profile, potentially transforming the therapeutic landscape for memory impairments and significantly improving patient outcomes."

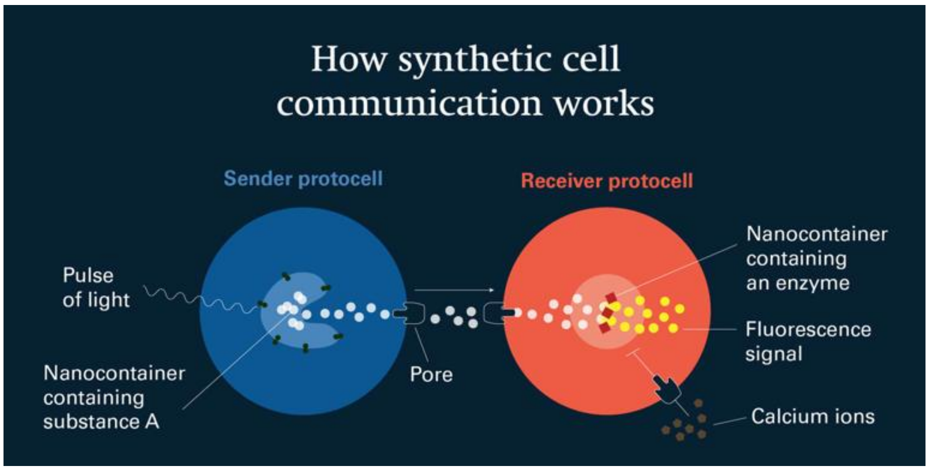
"These findings are exciting because they give us insight into what is happening in the brain between seeing something and saving it into memory," says Wilma Bainbridge, assistant professor of psychology at the University of Chicago, who was not involved in the study. "The researchers here are picking up on a cortical signal that reflects what's important to remember, and what can be forgotten early on."

More information: Benjamin Lahner et al, Visual perception of highly memorable images is mediated by a distributed network of ventral visual regions that enable a late memorability response, *PLOS Biology* (2024). DOI: 10.1371/journal.pbio.3002564

This story is republished courtesy of MIT News (web.mit.edu/newsoffice/), a popular site that covers news about MIT research, innovation and teaching.

Provided by Massachusetts Institute of Technology

Synthetic cells successfully emulate natural cellular communication



Schematic of synthetic protocells: Upon activation with a light pulse, synthetic cell organelles release substance A. The substance enters the receiver protocell and its synthetic organelle containing an enzyme. The enzyme converts substance A into a fluorescent molecule. Credit: Olivia Fischer, University of Basel

A research team from the University of Basel has succeeded in synthesizing simple, environmentally sensitive cells complete with artificial organelles. For the first time, the researchers have also been able to emulate natural cell-cell communication using these protocells—based on the model of photoreceptors in the eye. This opens up new possibilities for basic research and applications in medicine.

A team of researchers led by Professor Cornelia Palivan from the University of Basel and Nobel laureate Professor Ben Feringa from the University of Groningen reports on these findings in the journal *Advanced Materials*.

Life is all about communication: from bacteria to multicellular organisms, living things rely on their cells' ability to send, receive and process signals. Palivan and her colleagues carry out research into tiny containers made of polymers that they can load with specific molecules and open in a targeted manner.

In their current project, the team goes one step further. "We constructed cell-sized microcontainers packed with specialized nanocontainers," explains Palivan. This approach allows the researchers to simulate cells with cell organelles, creating a form of highly simplified synthetic cell also known as a protocell.

In their publication, the researchers describe a system of protocells made of polymers, biomolecules and other nanocomponents that is modeled on signal transmission in the retina of the eye. This system is made up of light-responsive protocells—the "senders"—on the one hand and receiver protocells on the other.

Within the sender cells are nanocontainers—essentially artificial organelles—whose membranes contain special light-sensitive molecules known as molecular motors. These allow the researchers to set communication between the two cells in motion using a pulse of light: when light reaches the sender cell, the light-sensitive molecules open the nanocontainers, releasing their contents—let's call it substance A—into the sender cell's interior.

Substance A can then leave the sender cell through pores in its polymer shell before reaching the receiver cell via the fluid surrounding the protocells. Then substance A enters the receiver cells—again via pores—where it encounters artificial organelles harboring an enzyme. In turn, this enzyme converts substance A into a fluorescence signal, and the resulting glow tells researchers that signal transmission between sender and receiver has worked.

In the photoreceptors of the retina that served as a model, calcium ions also play an important role, dampening the transmission of stimuli to the postsynaptic cells so that the eye can become accustomed to bright light. Similarly, the researchers designed the artificial organelles of the receiver cells in such a way that they react to calcium ions and the conversion of substance A into a fluorescence signal can be dampened.

A basis for synthetic tissue

"Using an external pulse of light, we succeeded in triggering an organelle-based signal cascade and modulating it with calcium ions. Producing a temporally and spatially controllable system based on the model of natural cell communication is a novelty," says Palivan.

The researchers' development sets the stage for synthetically emulating more complex communication networks of living cells—and thus for gaining a better understanding of them. There is also the possibility of creating communication networks between synthetic and natural cells and therefore of developing an interface between them.

In the long term, this could pave the way for therapeutic applications with a view to treating diseases, for example, or to developing tissue with synthetic cells.

More information: Lukas Heuberger et al, Photoreceptor-Like Signal Transduction Between Polymer-Based Protocells, *Advanced Materials* (2024). DOI: 10.1002/adma.202413981

Provided by University of Basel

Human proteins may explain inter-individual differences in functional brain connectivity, research suggests

A long-standing goal of neuroscience is to understand how molecules and cellular structures on a microscale give rise to communication between brain regions at the macroscale.

A study, titled "Multiscale Integration Identifies Synaptic Proteins Associated with Human Brain Connectivity," and published in *Nature Neuroscience* now identifies, for the first time, hundreds of brain proteins that explain inter-individual differences in functional connectivity and structural covariation in the human brain.

"A central goal of neuroscience is to develop an understanding of the brain that ultimately describes the mechanistic basis of human cognition and behavior," said Jeremy Herskowitz, Ph.D., associate professor in the University of Alabama at Birmingham Department of Neurology and co-corresponding author of the study with Chris Gaiteri, Ph.D., SUNY Upstate Medical University, Syracuse, New York.

"This study demonstrates the feasibility of integrating data from vastly different biophysical scales to provide a molecular understanding of human brain connectivity."

Bridging the gap from the molecular scale of proteins and mRNA to the brain-wide neuroimaging scale of functional and structural magnetic resonance imaging—a span of about seven orders of magnitude—was made possible by the Religious Orders Study and Rush Memory and Aging Project, or ROSMAP, at Rush University, Chicago, Illinois.

ROSMAP enrolls Catholic nuns, priests and brothers age 65 or older, who are without known dementia at time of enrollment. Participants receive medical and psychological evaluations each year and agree to donate their brains after death.

Herskowitz, Gaiteri and colleagues studied postmortem brain samples and data from a unique cohort of 98 ROSMAP participants. Their data types included resting state fMRI, structural MRI, genetics, dendritic spine morphometry, proteomics and gene expression measurements from the superior frontal gyrus and inferior temporal gyrus of the brain.

"Based on the stability of functional connectivity patterns within individuals, we hypothesized that it is possible to combine postmortem molecular and subcellular data with antemortem neuroimaging data from the same individuals to prioritize molecular mechanisms underlying brain connectivity," Herskowitz said.

The average age of the ROSMAP participants at time of MRI scan and at death were 88 +/- 6 years and 91 +/- 6 years, respectively, with an average time interval between the MRI scan and age at death of 3 +/- 2 years. The average postmortem interval to brain sampling was 8.5 +/- 4.6 hours. In the study, the researchers performed detailed characterization of each omic, cellular and neuroimaging data type, then integrated the different data types using computational clustering algorithms.

The key to the research was using an intermediate scale measurement—dendritic spine morphometry, the shapes, sizes and densities of the spines—to link the molecular scale with the brain-wide neuroimaging scale.

The integration of dendritic spine morphometry to contextualize the proteomic and transcriptomic signals was critical for detecting protein association with functional connectivity.

"Initially, the protein and RNA measures could not explain the person-to-person variability in functional connectivity; however, it all clicked once we integrated the dendritic spine morphology to bridge the gap from molecules to inter-brain region communication," Herskowitz said.

A dendrite is a branched extension from a neuron body that receives impulses from other neurons. Each dendrite can have thousands of small protrusions called spines. The head of each spine can form a contact point called a synapse to receive an impulse sent from the axon of another neuron.

Dendritic spines can rapidly change shape or volume while forming new synapses, part of the process called brain plasticity, and the head of the spine structurally supports postsynaptic density. Spines can be divided into shape subclasses based on their three-dimensional structure, such as thin, mushroom, stubby or filopodia.

This summer, in a different study, Herskowitz and colleagues used ROSMAP samples to show that preservation of memory in the very old was maintained by the quality, as measured by dendritic spine head diameter, not the quantity of synapses in the brain.

In this latest study, the hundreds of proteins the researchers identified that explain inter-individual differences in functional connectivity and structural covariation were enriched for proteins involved in synapses, energy metabolism and RNA processing.

"By integrating data at the genetic, molecular, subcellular and tissue levels, we linked specific biochemical changes at synapses to connectivity between brain regions," Herskowitz said.

"Overall, this study indicates that acquiring data across the major perspectives in human neuroscience from the same set of brains is foundational for understanding how human brain function is supported at multiple biophysical scales," Herskowitz said.

"While future research is necessary for fully determining the scope and components of multi-scale brain synchrony, we have established a robustly defined initial set of molecules whose effects likely resonate across biophysical scales."

More information: Multiscale Integration Identifies Synaptic Proteins Associated with Human Brain Connectivity, *Nature Neuroscience* (2024). DOI: 10.1038/s41593-024-01788-z

Provided by University of Alabama at Birmingham

F35 Helmet: Gen III Mounted Display System (HMDS)

Introduction

In the high-stakes world of multi-role tactical aircraft piloting, split-second decision-making can quite literally be a matter of life or death. As technology continues to advance, the tools available to pilots have become increasingly sophisticated, none more so than th**e F-35 Gen III Helmet Mounted Display System** (**HMDS**). This revolutionary interface offers pilots intuitive access to an extensive array of flight, tactical, and sensor information, ultimately enhancing situational awareness, precision, and safety to unprecedented levels.

A Glimpse into the Future

The F-35 Gen III HMDS serves as the pilot's primary display system, ushering in the next generation of cockpit interfaces. This innovative technology allows pilots to see through the bottom of the fuselage or directly at a target, providing an uninterrupted display of flight information and sensor data. The result is extreme spatial orientation, superior weapons targeting, and tactical superiority, whether it's day or night.

One of the standout features of this system is the seamless integration of the head-up display (HUD), helmet-mounted display, and visor-projected night vision. This integration empowers pilots with unparalleled capabilities inside the fighter cockpit. They can effectively target their weapons while maintaining advanced spatial awareness, all while continually monitoring crucial flight information.

The F-35 Gen III HMDS boasts an advanced bi-ocular display system with an expansive 30-by-40-degree field-of-view and a remarkable 100 per cent overlap. This feature becomes especially valuable during night missions, as the HMDS projects directly onto the visor, eliminating the need for separate night-vision goggles. Pilots can now seamlessly transition between day and night operations, further enhancing their flexibility and effectiveness.

Visual Targeting at Its Finest

One of the system's standout capabilities is the pilot's ability to target weapons simply by looking at and designating their intended targets. This innovative approach to targeting, combined with target verification through onboard sensors or datalink cues, streamlines the engagement process. It ensures that pilots can respond rapidly and accurately to threats, a critical factor in modern aerial combat.

Design and Comfort

Beyond its technical prowess, the F-35 Gen III HMDS also prioritizes the pilot's comfort and well-being. Its lightweight design maintains an optimal centre of gravity, enhancing overall manoeuvrability and reducing fatigue during extended missions. Additionally, the custom helmet liner ensures a precise fit, offering unmatched comfort that is essential for pilots operating under high-stress conditions.

Conclusion

In the ever-evolving landscape of aerial combat, the F-35 Gen III Helmet Mounted Display System stands as a testament to human ingenuity and innovation. It equips pilots with the tools they need to make split-second decisions, enhancing their situational awareness, precision, and safety to unprecedented levels. As we move forward into an era of advanced technology, this system serves as a beacon of hope for the brave men and women who protect our skies.

FAQs

How does the F-35 Gen III HMDS improve situational awareness?

The F-35 Gen III HMDS offers an uninterrupted display of flight information and sensor data, providing extreme spatial orientation, superior weapons targeting, and tactical superiority to pilots, day or night.

Can pilots switch between day and night operations seamlessly?

Yes, thanks to the advanced bi-ocular display system and visor-projected night vision, pilots can transition between day and night missions without the need for separate night-vision goggles.

How does visual targeting work with the HMDS?

Pilots can target weapons by simply looking at and designating their intended targets. Target verification is achieved through onboard sensors or datalink cues, ensuring accurate engagement.

Is the F-35 Gen III HMDS comfortable for pilots?

Yes, the system features a lightweight design with an optimal centre of gravity and a custom helmet liner for a precise fit, reducing pilot fatigue and increasing comfort.

What role does the F-35 Gen III HMDS play in modern aerial combat?

This system plays a crucial role by equipping pilots with the tools they need for split-second decision-making, enhancing situational awareness, precision, and safety in the ever-evolving landscape of aerial combat.

F-35 Gen III Helmet Mounted Display System (HMDS)

Unprecedented capability for the world's most advanced tactical aircraft

- Helmet Mounted Displays (HMD)/
- F-35 Gen III Helmet Mounted Display System

To the multi-role tactical aircraft pilot, split-second decision-making can be a matter of life or death. The F-35 Gen III Helmet Mounted Display System's next generation interface provides pilots with intuitive access to vast quantities of flight, tactical, and sensor information for advanced situational awareness, precision and safety.

Collins Aerospace CEVS JSF Helmet Mounted Display

Revolutionary Situational Awareness

The next-generation user interface serves as the pilot's primary display system, and virtual capabilities enable them to see through the bottom of the fuselage or directly at a target. With an uninterrupted display of flight information and sensor data, the pilot experiences extreme spatial orientation, superior weapons targeting, and tactical superiority–both day and night.

Integrated HUD, display and night vision

The head-up display (HUD), helmet-mounted display, and visor-projected night vision are fully integrated to provide pilots with unprecedented capability in the fighter cockpit. They can target their weapons and maintain advanced spatial orientation while continually monitoring critical flight information.

Bi-ocular display system with full day and night vision

Advanced bi-ocular, 30-by-40-degree-wide field-of-view has 100 percent overlap. For night missions, the HMDS projects directly onto the visor, eliminating the need for separate night-vision goggles

Visual targeting

The HMDS enables the pilot to target weapons by looking at and designating targets, and target verification when receiving steering cues from onboard sensors or via datalink.

High performance design with optimal center of gravity

The lightweight design has an optimal center of gravity and Active Noise Reduction (ANR). The custom helmet liner ensures precise fit and comfort for reduced pilot fatigue.

THE MODERN BATTLESPACE

BROUGHT TO YOU BY COLLINS AEROSPACE

The F-35 Helmet – a Modern Marvel That Creates a Unique Maintenance Challenge

"We get pilots from a wide range of backgrounds, including fighter and

helicopter pilots. Many of them have reported to us that this helmet system is the lightest, best-fitting and most stable they've ever experienced."
For the military pilot, the ability to perceive threats around their aircraft is the difference between life and death. To give military aviators immediate access and visualization of the data and intelligence they need to increase survivability and accomplish their missions, companies like Collins Aerospace have worked to display data in the most effective place for the pilot –in front of their eyes.

The personal-fit headgear display system utilized by the aviators flying America's next-generation F-35 joint strike fighter, offers unparalleled situational analysis, visual accuracy, and flight safety. To do so effectively, it needs to be custom-fit to the pilot, and any wear and tear that compromises that fit can have negative impacts on the wearer's ability to fly their mission.

The Modern Battlespace recently talked with Arthur De Ruiter and Dustin Vagedes of Collins Aerospace, about how the F-35 headgear outperforms helmets from the past. They also explained why wear and tear can be detrimental, and why maintaining these personalized fit helmets can be challenging.

The Modern Battlespace (TMB): *How are F-35 helmets and visors superior to prior models? What makes them unique?*

Arthur De Ruiter: The F-35 helmet and visor system is truly an engineering marvel that represents today's fifth-generation warfighter. The key difference between the F-35 helmet and a traditional fourth-generation warfighter helmet used on the F-16 is that all the flight and mission data is presented to the pilot on a display, mounted to the helmet.

"IF THE PILOT LOOKS AROUND IN CERTAIN CONDITIONS, THEY DON'T SEE THE COCKPIT OR EVEN THEIR LEGS… ALL THEY SEE ARE THEIR SURROUNDINGS LIKE TERRAIN" – ARTHUR DE RUITER

In addition, the helmet is connected to six infrared cameras located around the aircraft, providing a 360-degree view and unprecedented situational awareness. If the pilot looks around in certain conditions, they don't see the cockpit or even their legs. All they see are their surroundings like terrain, with the flight critical and mission data projected inside the helmet.

Dustin Vagedes: Indeed — the F-35 helmet is unlike any other in history. The Collins Aerospace F-35 Helmet Mounted Display System (HMDS) was designed to realize and exploit a true pilot-to-machine union.

"THE CONNECTION OF THE HMD TO THE AIRCRAFT IS UNIQUE FOR EACH PILOT… TO ACCOMMODATE TORSO LENGTH AND RANGE OF MOTION CHARACTERISTICS." – DUSTIN VAGADES

Weighing in at around five pounds, this system hosts an on-visor, bi-optical Heads-Up Display (HUD) to include digital night vision and imagery overlay from the aircraft's Distributed Aperture System (DAS), set to each pilot's interpupillary distance for optimal display quality. The connection of the HMD to the aircraft is unique for each pilot through different length interface cables to accommodate torso length and range of motion characteristics.

TMB: *Obviously, all equipment requires maintenance. How does wear-and-tear affect an F-35 pilot's helmet and visor? Does this headgear last a long time, or will it eventually deteriorate after a few years?*

Arthur De Ruiter: Inside the helmet shell are custom-milled pads that generally experience normal wear and tear. Other than being exposed to sweat or hair grease, they usually last a long time if the helmet is well fitted. Visors typically get scratched by frequent handling and need to be replaced more often. That can be a challenge because they must be custom-trimmed to fit the oxygen mask.

"ANYTHING THAT CREATES MINIMAL SPACE BETWEEN THE CRANIUM AND THE CUSTOM MILLED PADS CAN CREATE A PROBLEM OVER TIME, POTENTIALLY REQUIRING A HELMET REFIT AND UPDATED OPTICAL CALIBRATION." – ARTHUR DE RUITER

The need for helmet refitting becomes really important when physical changes are happening with the pilot, such as weight or hairstyle changes. Anything that creates minimal space between the cranium and the custom milled pads can create a problem over time, potentially requiring a helmet refit and updated optical calibration.

Over time, the pilot will notice if there are any issues by feeling uncomfortable "hot spots" or even double vision, which can lead to fatigue, headaches, and long-term neck injuries. It is important that pilots immediately report any of these issues to their life safety equipment teams, so they can contact Collins Aerospace to solve any fit issues.

Dustin Vagedes: These helmets have proven to be quite resilient. The F-35 has now logged over 400,000 flight hours to date and our 2,000-plus HMDs custom fit and delivered to date have held up well. The HMD system was designed to be operated and maintained in the most austere conditions our warfighters may be operating within. With this in mind, the HMD was designed with seven-line replaceable units (LRUs), that can be serviced or replaced in the field as necessary.

"THE HELMETS GO THROUGH A LOT DURING THEIR LIFETIME [WHICH WAS] CONSIDERED DURING THE DESIGN OF THE HELMET… TO REDUCE THE NEED FOR RETURNS TO THE FACTORY FOR MAJOR REPAIRS" – DUSTIN VAGEDES

The helmets go through a lot during their lifetime. Between missions, they are stuffed in the pilots' helmet bags and stored in their flight lockers. Helmet maintenance and cleaning are often performed by schedule-saturated technicians, who may be stressed with meeting their assigned time-sensitive missions. Pilots can even bang the helmets against things in the cockpit while doing aggressive head turns while checking their "six". All these things were considered during the design of the helmet and factor into continuous design improvements to reduce the need for returns to the factory for major repairs — saving our customers and our end users money in the long run.

The helmets hold up quite well over time. It's the visors that are most likely to need replacement since they're supposed to be clean and clear but are exposed during use and storage. Any scratches on the surface of a visor might become an annoyance to a pilot even if they don't affect helmet functionality.

TMB: *What has the process traditionally involved for replacing a pilot's helmet and visor? Can they just use replacement parts, or is there a process that must be followed?*

Dustin Vagedes: The previous helmet-mounted display systems have typically been built around a fairly universal helmet shell and require extensive modifications to replace and/or reconfigure for their specified use and reuse.

The Collins Aerospace F-35 HMD's consistent configuration and integrated design provide a repeatable fit as replacement parts are installed.

The custom-milled liner and visor files are retained indefinitely and are provided to the end-user to further ensure continuity of the performance and fit. These replacements are typically provided by the services-life-support personnel who follow the OEM maintenance process to return a helmet to service, after being trained or re-trained by Collins Aerospace.

Arthur De Ruiter: In the current fitting process, pilot cadets will get their new helmet fit at a Pilot Fit Facility, typically at a US Air Force Base like Luke. This is a two-day process and after they have been fitted, they go straight into their extensive training program. Unless there is a major problem with the helmet seen during training flights, we typically do not see the pilot again.

"IF ANYTHING HAPPENS TO THE HELMET… THEY WOULD NEED TO GO THROUGH THE ENTIRE FITTING PROCEDURE AGAIN, WHICH MEANS RETURNING TO AT PILOT FIT FACILITY IN THE US." – ARTHUR DE RUITER

Once they become deployed at their home base and fly extensive hours, they are on their own to work with the services-life-support teams. If anything happens to the helmet that affects the perfect fit beyond what can be resolved with a simple replacement part, they would need to go through the entire fitting procedure again, which means returning to at Pilot Fit Facility in the US. Fortunately, Collins Aerospace has developed a technology that will get pilots back in the air sooner, by bringing the solution to the customer.

Designed to work with the F-35 Lightning II, the custom-fitted helmet serves to increase pilot responsiveness through enhanced situational awareness. Real-time imagery from the aircraft's six exterior cameras is streamed onto the helmet's display providing the pilot a view that would otherwise be obscured. (U.S. Air Force photo by Senior Airman Erica Webster)

An inside look at F-35 pilot helmet fittings

- Published Aug. 5, 2021
- By Senior Airman Erica Webster
- 419th Fighter Wing Public Affairs

HILL AIR FORCE BASE, Utah (AFNS) --

Reservists in the 419th Operations Support Squadron play a crucial role to ensure the safety of pilots assigned to the **419th Fighter Wing**, the **Air Force Reserve**'s only combat-capable **F-35 Lightning II** unit.

"We are responsible for maintaining and repairing pilot gear to ensure everything is in proper working condition," said Staff Sgt. AJ Arteaga, 419th OSS aircrew flight equipment Reservist. "That also includes their helmet."

Every helmet is custom-fitted to its pilot during a two-day process at a fit facility. To begin assembly of the helmet, pilots have their heads measured and scanned to secure the perfect fit.

Tech. Sgt. Anthony Farnsworth, 419th Operations Support Squadron, adjusts an F-35 Lightning II helmet during optical fit training at Hill Air Force Base, Utah, July 10, 2021. Each helmet is inspected every 105 days and has a 120-day fit check to ensure its functionality and safety. (U.S. Air Force photo by Senior Airman Erica Webster)

Staff Sgt. AJ Arteaga, 419th Operations Support Squadron, adjusts the head position of Tech. Sgt. Anthony Farnsworth, 419th OSS, during F-35

Lightning II helmet optical fit training at Hill Air Force Base, Utah, July 10, 2021. Reservists in the 419th OSS are responsible for maintaining and repairing pilot gear to ensure it is in proper working condition. (U.S. Air Force photo by Senior Airman Erica Webster)

Tech. Sgt. Anthony Farnsworth, 419th Operations Support Squadron, demonstrates the F-35 Generation III Helmet-Mounted Display at Hill Air Force Base, Utah, July 10, 2021. The display provides the pilot critical information, built-in night vision, and allows a 360-degree view of the aircraft's outside environment. (U.S. Air Force photo by Senior Airman Erica Webster)

Once assembled, pilots need to have the optics aligned using a pupilometer, which measures the distance between their pupils within two millimeters of its center, so pilots see a single image on the helmet-mounted display.

On the display, pilots are able to view mission-critical information and obtain enhanced situational awareness of the battlefield simply by moving their head. The helmet gives pilots a 360-degree view of the F-35's external environment without needing to tip the jet.

"The pilot can look down through a portion of their wing and see what's below," said Tech. Sgt. William Vass, 419th OSS. "When they look toward the cameras embedded on the F-35 that image projects onto their helmet display."

The helmet's innovative technology and precise fit require routine maintenance so pilots can complete their mission. In addition to pre- and post-flight fittings, the helmet is inspected every 105 days and has a 120-day fit check to ensure its functionality and safety.

“Pilots come in and put on all their gear so we can double-check to make sure everything fits properly and without issue,” Arteaga said. “Small things such as a new haircut or a couple of pounds gained could cause the helmet to not fit correctly.”

Mask adjustments are also included within the helmet fitting. Pilots are sent to an oxygen tester where aircrew flight equipment technicians can identify any leaks around the mask that could prevent adequate oxygen flow.
"The pilot can look down through a portion of their wing and see what’s below. When they look toward the cameras embedded on the F-35 that image projects onto their helmet display.”*Tech. Sgt. William Vass*

“The next part is to ensure there is a proper distance between the mask and the visor,” Arteaga said. “We have to make sure when the pilot moves or talks, the mask doesn’t hit the visor. If it’s too close, it will bend the visor and distort the display image.”

Reservists in the AFE shop are an integral part of the helmet-fitting process and maintenance intervals. They verify it remains as precise as possible to guarantee the safety of the 27 pilots in the 419th FW. The work is involved and in-depth, but essential to providing a seamless interaction between the helmets’ advanced capabilities and the exacting skills of the pilot wearing it.

F-35 HELMET, AHEAD OF OUR TIME

When the DoD launched the acquisition process for the revolutionary multi-service, multi-role, single seat, single engine strike fighter aircraft known as the F-35 Lightning II, they envisioned a common platform across three variants that ultimately invigorated the defense industry world-wide, creating an influx of new technologies — notably the F-35 helmet.

A vital element of the F-35’s unprecedented warfighter capability, the helmet's ground-breaking technology equips the pilot with mission-critical information on the helmet's visor; resolves well-documented fit, comfort, and convenience problems associated with helmets worn by pilots of legacy aircraft; and fuses together the F-35's cutting edge communications and sensor suite to form a clear picture of the operating environment — giving F-35 pilots unrivaled situational awareness and a decisive advantage over adversaries.

The latest iteration — known as the Generation III helmet — is also easily realigned and readjusted based on the individual pilot's needs, whereas previous legacy F/A-18 helmets are rigid, cumbersome, and require manual upgrades.

While onboard the amphibious assault ship USS America (LHA 6) during the third and final shipboard phase of F-35B Lightning II developmental test (DT-III), Marine Corps Sgt. Nicholas Voegeli and Desirée Smith, F-35 Lightning II Pilot Systems Integration-Human Systems engineer, demonstrated the advancements featured in the F-35's Gen III helmet.

Fabricated with its own Display Management Computer Hardware operating system the helmet enables pilots to toggle through different modes of data visualization. It also delivers a more efficient video feed than the F-35's Gen II helmets — equipping pilots with symbology correlated inside the cockpit as well as outside the aircraft with the use of the Distributed Aperture System (DAS). Using multiple DAS cameras installed peripherally around the aircraft, the pilot is able to display various modes of imagery such as thermal, night vision, and actual and achieve an unprecedented look-through-aircraft capability. All modes are beneficial to pilots as they deliver a clear 360-degree picture during daylight and lowlight settings. Thermal images portrayed through DAS enable pilots to view heat signatures emitted by various objects. For instance, a pilot can identify a ship running a hot engine against the vast darkness of the cold ocean. Night vision can also assist in magnifying low visibility objects against areas of very little to no light.

"The helmet mounted display (HMD) allows critical flight data to be viewable anywhere I look," added Marine Corps Major John "IKE" Dirk, a test pilot and the F-35B DT-III Officer-In-Charge (OIC) from the Pax River

Integrated Test Force (ITF) assigned to Air Test & Evaluation Squadron (VX) 23 based at Naval Air Station Patuxent River, Maryland.

“In addition to the aircraft’s flight symbology, I can display tactical data and even live night vision video. The helmet helps me find friendly and enemy aircraft, locate targets on the ground, and can even point out the ship. It is fully integrated into the aircraft systems and enables a seamless transition between tactical display and the outside world,” he added.

Joint Helmet Mounted Cuing System (JHMCS) helmets worn by pilots of legacy jets such as F/A-18 Hornets, Super Hornets, and AV-8B Harriers, take a long time to install equipment enhancements while F-35 Gen III helmets are specially designed to facilitate the quick installation of equipment, thereby reducing the maintenance time required for each helmet.

Another problem with JHMCS legacy helmets is the graphics on the display visor, which block the pilot’s ability to see through an overly bright image. Engineers worked to refine this imagery on previous iterations of the Gen III helmet and now the latest helmet enables pilots to toggle through several gradients of opacity. The pilot is also able to devote less time switching through different modes and doesn’t have to physically install Night Vision Goggles before starting a night mission because the Night Vision Device (NVD) is built-in.

“Legacy systems are often limited to a fixed heads-up display or separated into several systems — targeting helmet, night vision goggles, heads up display, etc.,” Dirk said. “The F-35 helmet integrates all of these capabilities and more into one balanced and comfortable helmet, complete with active noise reduction.”

These technological advancements of the F-35 Gen III helmet will save military expenditures due to several new factors.

The use of laser scanning technology creates an exact replica of a pilot’s skull, thereby fabricating a portable styrofoam helmet liner that is a break-through above and beyond the traditional custom-designed helmet for each pilot. This styrofoam cap fits into any size helmet, enabling a pilot to take the helmet liner from squadron to squadron for use throughout his or her career, optimizing the flexibility of the pilot flight equipment inventory, eliminating risk of damage to helmets during squadron transitions, and reducing investments in large inventories of helmets.

As the pilot dons the cap and helmet, two ocular cameras situated above the helmet's display visor are manually aligned to his or her interpupillary distance (IPD) settings for each eye to ensure the acuity of each pilot's vision and establish the proper fit of each helmet.

“The helmet is definitely well worth it considering what it brings to the fleet, the capability it brings to the warfighter who keeps us safe, and how it equips all of the pilots,” said Smith, referring to the clear 360-degree picture of the battlespace that the helmet delivers.

This unrivaled situational awareness equips the pilot with an unparalleled ability to dominate the tactical environment. Likewise, commanders at sea, in the air or on the ground immediately receive information collected by the F-35's sensors via data link — empowering them with an instantaneous, high-fidelity view of ongoing operations, making the F-35 a formidable force multiplier while enhancing coalition operations.

Additionally, legacy aircraft only displayed targets on screens installed inside the actual cockpit, creating a disadvantage because pilots would have to turn their heads away from their surroundings. Now, F-35 pilots can focus on their targets via the Gen III helmet display visor. This empowers them to keep track of adversaries farther than they could ever turn their heads.

"You can't put a price on the blanket of freedom that this aircraft will deliver,” Voegeli added. “The threat of any adversary who wishes to bring us harm is ultimately the reason to test this next generation fighter jet. The moment this aircraft is put in the fight all questions will come to an end."

The quantity of specifications in this piece of revolutionary equipment showcases the DoD's integration of pilot equipment with its next generation strike fighter, its focus on warfighter performance and pilot safety, and its ability to inspire technological advancements that ensure U.S. air combat superiority for generations to come.

"High intensity training for the mind": A neurosurgeon explains why we dream

I woke up exhausted this morning. It's not that I didn't get a good sleep — I did. It was just an incredibly busy one, full of running, climbing and at one point flying across a room. As I opened my eyes to the new day, it took a few moments to realize that I had not, in fact, spent a night engaged in intense, impossible physical activity. "Our brains are not resting when we sleep," explains Rahul Jandial, MD, PhD, whose latest book is "This Is Why You Dream: What Your Sleeping Brain Reveals About Your Waking Life."

In it, Jandial, a Los Angeles neuroscientist and neurosurgeon, explores why the brain stays active even as the rest of the body is dormant, makes the case for nightmares, unlocks the health signals our sleeping minds may be trying to tell us and reveals the new science of how to potentially give ourselves a more interesting, aware dream life. I talked to Jandial recently via Zoom about the mystical, sometimes "transcendent state" of dreaming, and why you can't do math when you're asleep.

This conversation has been edited and condensed for clarity.

You open this book with the evolutionary case for our dreams. Why do we need to dream?

The answer is based on neurodevelopmental biology. The fundamental principle of neurons, neural tissue, is that either you use it or you lose it. When we look at brain activation, brain electricity and glucose utilization, our brains are not resting when we sleep. In fact, the electricity can be seen as equivalent. The question then is, what is going on with the brain activation? Imagination and emotion are being liberated, meaning those neurons are activated. They're using up glucose, they're sparking electricity through neurotransmitters that typically aren't during waking life.

My big theory is that it's high-intensity training for the mind so we're not constrained by just the limited parts of our brain we use during the day. It keeps our thinking creative, and it keeps us adaptive as a species. When you look at the waking brain and the dreaming brain, it's quite different areas, and they don't overlap much. My best guess, based on those principles, I think is a new and fresh look to dreaming, that it is not a restful state. It is vibrantly active.

Some of us always remember our dreams and seem to experience them very vividly, while other people say they never dream. They never think about their dreams; they never remember their dreams. Do you think our dreams then are having the same impact on us in relation to our waking selves?

The way to tackle that is to look at the dreaming pattern throughout life. We've all had a nightmare, we've almost all had an erotic dream at some point. We know what a dream is. They arrive as a universal experience. Clearly, we remember some dreams. Nightmares, in particular, by definition, wake you up and sear you with that memory. I feel like in adulthood we get this variety of dream recall.

Those people who recall vivid dreams versus those who don't, they have the same brain electricity and the same brain glucose utilization between them. So I think the dreaming process is churning, no matter what the memory. The dream recall varies. And that residue you were talking about is very important. The dreaming brain turning into waking brain is not a crisp moment. There are a few seconds of lingering transitions, called sleep exit. That's an area where you can hold onto a dream memory. People can cultivate this a bit. You can recall your dreams more. Not always, not every time. But just to know that that capacity is there, albeit limited, is fascinating to me. It bookends the sleep entry period, going from waking brain to dreaming brain. There are a few minutes there were people like Salvador Dali said they extracted interesting ideas. So while the recall is variable, the dreaming process is happening robustly in all of us.

I would imagine that there is some correlation around being awakened mid-dream as opposed to awakening in a different sleep cycle.

I didn't find too much about that. Conceivably, a third of our lives is spent dreaming. Towards the end, when we wake up, the dreams tend to be more vivid, the REM cycle also changes. What's fascinating to me about that is that the dreaming process is not something we choose. Sleep is not something we choose. Sleep insists. If you skip a day of sleep. as I did in surgical training, often the next day when you sleep, the REM cycles and the dreaming reports shift to earlier and harder. That's a big statement.

When you're asleep, your body temperature is about the same, a little cooler, the EKG on your heart releases a few sparks that we're familiar with. Inside the skull, it's throbbing with heat, electricity and brain waves. The brain is making us sleep. And what does the brain do when we sleep? It dreams. The most vibrant activity it does is dream. When you look at any system like that, that's not an incidental feature like an appendix. That is a massive process, universally applied across mammals, across other species. I think it's what a collection of neuronal tissue needs to be most adaptive, to be to have that clarity during the day. It's not that the brain is revved down like a computer screen and you click the keyboard and it comes up. It's at that electrical level that dreaming provides the brain a certain rest, almost, that gives us clarity when we wake up. Those are the big concepts that I'm seeing.

It speaks to an intersection that a lot of us are not always comfortable with. You can't just stay in the science realm here. This is philosophical, what you're talking about here.

When they asked me to prepare this book, I said, "I just need to have one permission — that where there will be gaps of knowledge, I want to say, "I believe. Could it be? I wonder? Wouldn't it be an elegant hypothesis?" I want to be upfront with people. There's no way to say that nightmares arrive in kids to cultivate their sense of self versus other. I can tell you that they arrive at the same time as another capacity called theory of mind, where it becomes, "Somebody smiling doesn't always mean some goodwill for me." When I put those things together, it's an invitation to people to think about, why do we have to tell Johnny, 'It was only a dream?" That invites the thought that waking thought and dreaming thought before nightmares arrive are blurred. Why do nightmares cluster in families? Falling dreams and teeth falling out dreams don't. I wonder if those universal processes that come through families show where there's a cognitive inheritance, like risk-taking.

To do this as a brain surgeon adds a certain rigor to it. There are people who are dismissed for bringing in feelings of supernatural or transcendent states, and they're made to sound fringe. What I'm trying to say is, look, lucid dreaming sounds fringe? Lots of science for that. I'm trying to shed light that some of these universal experiences are actually science-based.

We know that we think differently. Some of us think more in words and some of us don't. Some of us think more visually, some of us don't. It makes me wonder about the ways in which we think in our waking lives are reflected in the way that we process or experience our dreams.

When we look at thousands of dream bank reports, nightmares are universal. Math is very rarely reported. The big major change in the waking brain and the dreaming brain is the executive network, not one spot, but a collection of structures, a symphony that is dampened, allowing for illogical jumps and movie-like scripts. It makes sense with what we know about the dreaming brain’s activation and deactivation. The dreaming brain does not calculate, does not do reason.

[Dreams] tend to be hyper-visual, hyper imaginative. It's a hyper emotional brain at a top speed your waking brain can't get to. That’s why you wake up sometimes with the residue of that feeling, “That just happened.” It starts to make sense why the emotional dreams have a residue. In the dreaming brain/mind, there’s very little calculation. Movement, falling, running feel real, because those neurons in the motor strip are actually firing, generating that electricity we can measure. It's just that they’re not sending the signals down to your body. Dreams are thoughts, experiences from a brain in a different tapestry of activation. That's how people want I want people to think about it. It’s 24 hours in your head.

And thinking and dreaming are not the same. That's a really important distinction.

Thinking is directed, with the executive network on task. Adrenaline is up. The dorsolateral prefrontal cortex is looking outward, looking for the signal and the noise. The dreaming brain is executive network dampened, adrenaline dampened. Then your internal imaginative mental workspace is liberated, and that divergent thinking isn't trying to achieve a goal. It's bouncing around. It's ricocheting; it’s making looser associations. And maybe when we wake up, or a week later, we have an aha moment during the day. It's not from the triple espresso. It's from this dreaming process that is loosening the associations by design. I think that's the most romantic, big way of thinking of it.

Let's talk about nightmares. You talk in the book about the purpose that dreams can serve us, and you make that distinction between people who are processing PTSD and the kinds of nightmares that all of us experience day to day. Why do we have nightmares?

Big question. When I was telling people I was writing a book on dreams and dreaming, the first thing they were asking was, "Surely nightmares have to be a glitch or a mistake?"

Nightmares can be understood by breaking them down into age groups, pediatric and adult. Pediatric ones arrive universally. They may cultivate the sense of self versus other. They prompt us to teach our children that what you're thinking and experiencing in this state is not reality. That's a big thing to teach kids, and then they almost always fade. There are very few nightmare disorders in children. To me nightmares in children are cultivating the mind in some way. They arrive and they dissipate over a pattern of a few years.

In adults, they can come in PTSD flashbacks, which is a bad experience memory on a loop. Then there's the adult nightmare that occasionally happens. It's a byproduct I think of the imagination network. The lessons that I found there are that for people who don't have nightmares, if new nightmares arrive, they're persistent, they get worse, that's something to pay attention to. Nightmares there may be the warning signs for things, like they are for Parkinson's. There are literature studies coming out for lupus and autoimmune diseases. The first alarm is a change in the dreaming pattern, specifically nightmares.

Nightmares serve a function in children. In adults, that may be our earliest warning bell for some changes that are happening. Not always, but potentially. I would say maybe they should be considered a vital sign like temperature, blood pressure, something that something that patients should report, particularly in the mental health space.

You talk in the book about how not just nightmares, but dreams in general can be telling us something about our health. We don't talk to our doctors about this.

Until now. Now we know dreams are not random. They're our brains in a different mode. Dreams are a knock on the window from our hyper-emotional, hyper-imaginative brain state. That doesn't mean every dream has to make sense.

They're going to be symbolic. They're not rational. But dreams are a fundamental process. So the next dream I have, I might not be so quick to forget it or think it's completely insignificant.

You talk about lucid dreaming, and how small a percentage of people, it seems, can actually really do it. But all of us can do things to maybe have a more pleasant experience when we close our eyes at night. What's going on, and what are the limitations?

The best example for that is something called imagery rehearsal therapy, rescripting your nightmares. Even if that happens only occasionally and only in some people, what a concept, that you can redirect the product of your imagination, that you're not just a victim of your nightmares, and that reimagining can actually change the electricity and the neurotransmitters and the pharmacy of your own brain.

Lucid dreaming is interesting. To be clear, lucid dreaming is the return of awareness within a dream, not asleep entry, not asleep exit. The most rigorous science by dreaming is actually about lucid dreaming. Here's what I've found — consistent reports show a third of people do it. It doesn't mean all night long, it's a fragile state.

Here are four quick tidbits of proof on it. With surface electrodes, we can prove if somebody's asleep, you can't fake that. People go to sleep labs and use left-right, left-right eye communication to communicate wirelessly. Then there's Galantamine, an acetylcholine drug for dementia. Patients who take come in saying they're lucid dreaming. If we double the dose, they're lucid dreaming more. Dose-dependent escalation shows cause and effect, and that it's a biochemical process. You take a pill, and you lucid dream more, so it's not just reporting. The third thing is that people in the scanner show that [in lucid dreaming] the executive network comes back online a little bit, because people are starting to do Morse code eye movements to do simple math. As a little bit of awareness comes in within your dream, a little bit of math capacity seems to come back. That's strong science storytellingt. And then the last piece is with the left-right eye method to cultivate lucid dreaming, the one that's called MILD. They had a bunch of people use the technique, come into the sleep lab and prove with their eye movements that they could lucid dream more. It reminds us all that's not crisp — awake, asleep, awake, asleep.

How has writing this book and doing this research changed how you look at your own dream life, and how you understand dreaming?

The exploration of dreaming left me with things that were revelatory. Sleep entry and sleep exit are the application that I can extract better ideas, more creative ideas. Sleep entry, I can extend it. Sleep exit, I always wake up slowly and try not to go on Instagram and write a few notes. I know there's an interesting way of thinking I have there. I get a lot of ideas that sleep exit — good ones and bad ones — but that's really my idea generator.

That said, two other revelatory things. One is dream enactment behavior. Men in their fifties, if they act out their dreams, almost invariably develop Parkinson's later. The physical withering of the brain and mind, its first warning flare is a changing dreaming pattern. Within that, please look up paradoxical kinesis. When people have Parkinson's and their movements are rigid and the speech is stifled, and they act out their dream, their movements are fluid and their speech is loud and clear. The dreaming mind in Parkinson's removes the physical symptoms of the body. That makes no sense.

The second thing is that the one or two minutes after our heart stops, that last gush of blood in our carotids and vertebral to our brain, the brain doesn't whimper to death, like a liver or a heart. The brain with that last gush of blood somehow knows. It explodes with neurotransmitters, and a burst of electrical brainwaves that look like a massive dream and memory recall. That's a measurement. We've got people whose hearts show nothing one minute afterwards. Measurements. That's not my opinion. That explosion of brainwaves happens in the minute or two after the cessation of electrical activity on EKG. How beautiful is that? That our brain’s last act is to go out with a salvo of experience and emotion and feeling?

New study reveals how the brain orchestrates motions in partnership with sensory cues from the body

Microscope image of a fly brain (gray) with magenta visual neurons connecting to a motor neuron in this study (green). Credit: Stephen Huston, Zuckerman Institute; Rebecca Johnston, Friday Harbor Laboratories© Provided by Medical Xpress

Motor neurons are the cells the brain uses to command muscles to act.

Scientists typically thought of them as simple connections, much like the cables that link computers with their accessories. Now, in fly studies, researchers at Columbia's Zuckerman Institute have discovered that single motor neurons can each direct an insect's body to move in far more complex ways than previously thought.

The findings were published in *Nature*.

"This is one of the first times scientists have analyzed in 3D what single motor neurons do while the body moves naturally," said Stephen Huston, Ph.D., an associate research scientist at Columbia's Zuckerman Institute, and the study's corresponding author.

"You can't understand how the brain makes the body move without knowing what each motor neuron does, just as you can't understand how a puppeteer makes a marionette move without understanding what the puppet strings do."

Motor neurons are the final links through which the brain controls the body's motions, from a flick of a finger to a blink of an eye. Despite this pivotal duty, researchers are only now beginning to uncover the role that single motor neurons play in movement. Measuring the activity of individual neurons in moving animals has proven to be experimentally difficult.

Now advances in laboratory techniques have made it possible for researchers to manipulate single motor neurons in fruit flies as the insects move freely.

In experiments that began at the Howard Hughes Medical Institute's Janelia Research Campus in Ashburn, Virginia, the first step for the researchers was to activate light-sensitive molecules in the 25 or so motor neurons that control head movements of the sesame-seed-sized fly. This enabled the scientists to use red light to switch on motor neurons one at a time. At the same time, they recorded the resulting head motions while using artificial intelligence techniques to track these movements.

"Most neurons act in concert as a population, so we didn't expect to see much or even any head movement at all when we activated just one motor neuron at a time," Dr. Huston said.

At most, the scientists had expected that each single motor neuron was hardwired to produce one simple motion—for instance, making the head turn left 10 degrees. Instead, through computational analysis later performed at the Zuckerman Institute, the researchers discovered that activating each motor neuron could make the head rotate in a variety of ways, some even in opposite directions from each other, depending on the starting posture of a fly's head.

"I was really excited about how specifically we could activate individual neurons to drive these motions," said Benjamin Gorko, a Ph.D. student in the molecular, cellular, and developmental biology department at the University of California, Santa Barbara, and the study's first author.

The scientists liken this kind of motor control to a digital thermostat, where punching in a desired temperature will cause a room to warm up or cool down depending on the current room temperature. In much the same way, when the researchers stimulated each motor neuron, the fly's head moved towards a pose specific to that motor neuron, with the insect's head rotating one way or the other to reach that desired position depending on its starting posture.

The research team's thermostat-like model suggests that when the brain wants to move the body a specific way, it cannot simply stimulate the same set of motor neurons each time and expect the same result. Instead, the brain must calculate which motor neurons to activate based on sensory data it receives about the body's current posture. Indeed, deactivating sensory neurons that monitor the fly's head position altered how the insect moved when the scientists stimulated the motor neurons.

Pinpointing what the brain does on the cellular level in fruit flies is more than just an academic exercise. "A better understanding of what motor neurons do can help us understand diseases that affect the motor system, such as amyotrophic lateral sclerosis, also known as ALS or Lou Gehrig's disease," Dr. Huston said.

Next, the researchers want to investigate how other kinds of neurons in the fly, such as those in the visual system, interact with motor neurons to control movement.

More information: Stephen Huston, Motor neurons generate pose-targeted movements via proprioceptive sculpting, *Nature* (2024). DOI: 10.1038/s41586-024-07222-5. www.nature.com/articles/s41586-024-07222-5

Provided by Columbia University

Neuroscientists discover complex genetic programs at the root of our movements

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

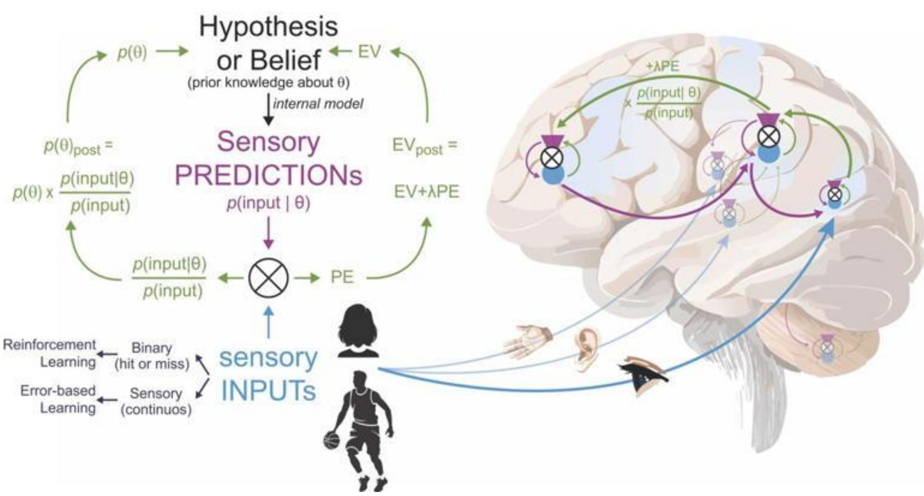
"Understanding how corticospinal neurons emerge during development and how they project into our central nervous system is important, as they are essential for fine motor skills. However, they are highly sensitive to spinal cord injury or to the consequences of amyotrophic lateral sclerosis, a disease 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

Provided by University of Geneva

How the brain plans ahead to predict the world



How predictive coding, Bayesian inference and learning processes come together. Credit: Neuroscience & Biobehavioral Reviews (2024). DOI: 10.1016/j.neubiorev.2024.105877

Your brain not only processes what you see but continuously makes predictions based on your experiences. This process may be less finetuned in people with autism.

When someone throws a ball at you, you almost immediately know to catch it—even before you consciously realize it. In the past, people thought that in such a situation, the brain functioned like a camera: an image of the flying ball enters through your eyes and is then processed by your brain. The brain then programs an appropriate action to react to it. But doesn't that process take too long? Would you still be able to catch the ball in time?

Researchers Christian Keysers, Giorgia Silani, and Valeria Gazzola show that this process in the brain works differently. Christian explains, "Your brain doesn't react to what enters the eye—but it predicts what will happen, based on expectations and previous experiences. By doing so, our actions keep pace with the ball, despite the hundreds of milliseconds it takes the brain to process visual input and move our body.

"It plans ahead to allow time to execute the action and catch the ball. The image that enters through your eyes is mainly used to check if your expectations match reality. Only when there's a difference between your expectations and what you see, does your brain use the visual input to nudge its expectations in a more accurate direction."

The research is published in the journal *Neuroscience & Biobehavioral Reviews*.

Predicting others

Gazzola says, "What's interesting is that you also use your own motor programs and somatosensory cortices to predict the actions of others. When you perform a physical action, like lifting a carton of milk to pour some of it into your coffee, you have expectations about the weight of the carton, and how it should feel in your hand when you start lifting it.

"You don't really notice the weight of the carton consciously, because your brain predicted it. But if someone else has already finished the milk, and the carton is so much lighter than you expected, the sudden difference between your expectations and the sensory feedback suddenly grabs your attention.

"When you see someone else do so, you don't directly feel the weight of the carton. Still, you can make predictions using your own motor programs, and test them against what you see. So, you still feel surprised if the carton flies skywards much faster than you expected.

"We think this has to do with so-called mirror neurons, which are cells within your own motor cortex that become active when you see someone else perform an action. This acts as a sort of 'shortcut,' allowing you to use your own motor programs, and the predictive machinery necessary for your own actions to predict the behavior of others."

But what about emotions? Gazzola explains, "We know that regions in our brain that are involved in our own emotions become active while we witness the emotions of others. However, how we predict the emotions of others is not fully understood. Reviewing the literature revealed that the regions in our brain that are active when we receive reward or punishment also become active when someone else receives reward or punishment. Reward and punishment are therefore valuable predictors for the emotions of others."

Complex system

Keysers says, "Imagine I have a button, and every time I press it, an actor starts screaming in pain. If I do this five times, your expectations change: the first time, it's totally unexpected, but by the fifth time, you can predict what will happen.

"According to the traditional theory of perception, where the brain only processes the image you see, you should see the same reaction in the brain each time. But if the outside world primarily serves to test your predictions, you'd expect a strong brain response the first time, and a much smaller response the last time, because you already know what's going to happen.

"So what actually happens in the brain? Over many studies, we see that it's quite complex. Some brain areas respond relatively consistently across all five times. At the same time, there are also brain regions where activity changes across the five times. In this review paper, we look at the many studies that have emerged on the topic to propose how these different brain systems organize into a coherent predictive brain.

"For example, if some actions become predictable, your premotor cortex knows how to perform the action in your body. This region will then inhibit visual regions in your brain, leading to less visual input. What you perceive is then no longer what you actually see, but what you expect to see. Only if something unexpected happens, does this inhibition become ineffective. The visual areas now show a strong response that is sent forwards to the premotor cortex to revise the predictions."

Predictions and autism

It's believed that the predictive system in people with autism is less well-tuned. This makes the world around them more unpredictable, leading to less suppressed stimuli.

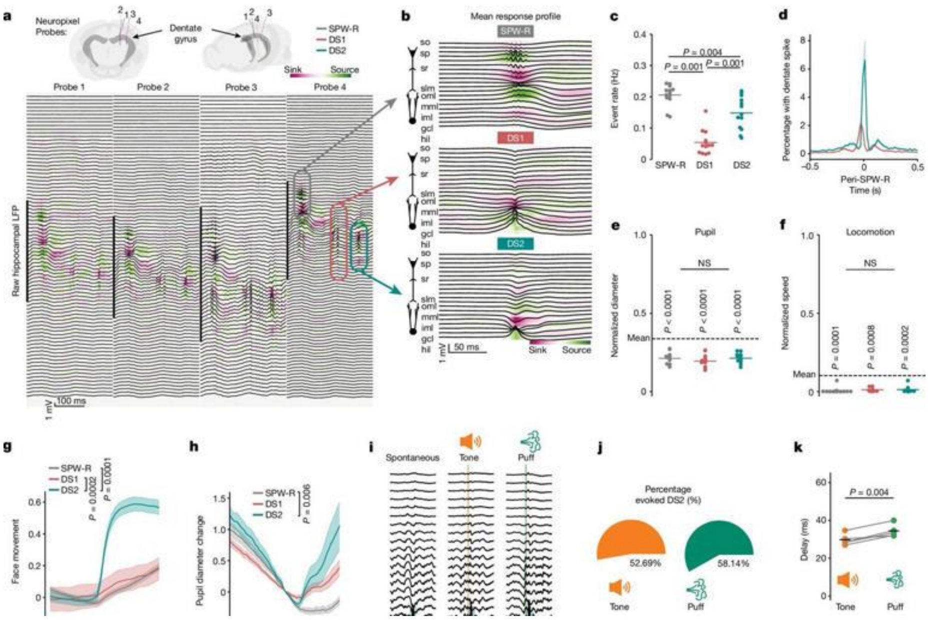
Keysers explains, "Imagine you're standing in a crowded room with many people. Because our brain makes a lot of predictions, we can ignore most stimuli and focus only on what's important. But when this predictive system doesn't work well, such a busy environment can suddenly feel overwhelming.

"The brain is complex and has the unique ability to adapt. It's interesting to realize that your brain isn't just a camera simply processing what comes in. Instead, your brain constantly operates based on predictions. Your brain is always ahead and continuously constructs what the world should be."

More information: Christian Keysers et al, Predictive coding for the actions and emotions of others and its deficits in autism spectrum disorders, *Neuroscience & Biobehavioral Reviews* (2024). DOI: 10.1016/j.neubiorev.2024.105877

Provided by Netherlands Institute for Neuroscience - KNAW

How the brain wakes us from daydreams



Distinct behavioral correlates of DSs. Credit: Nature (2024). DOI: 10.1038/s41586-024-07192-8© Provided by Medical Xpress

When we daydream, we must be able to snap back to attention at a moment's notice. Researchers at Boston Children's Hospital uncovered how our brains can do things like react to a question when we're daydreaming: firing activity in part of the brain called the dentate gyrus keeps us focused on what's happening in our environment. And the team found that the same neural activity also helps with forming memories. The findings were published in *Nature* on March 13, 2024.

"We have found a brain mechanism for breaking up periods of mind wandering and realigning the 'cognitive map' back to reality," says Jordan Farrell, Ph.D., an investigator in the F.M. Kirby Neurobiology Center and Rosamund Stone Zander Translational Neuroscience Center at Boston Children's.

It's known that during sleep or periods of daydreaming, our brains replay past events in a form of synchronized activity known as the "sharp-wave ripple." This enables us to consolidate our memories.

Analyzing data from a mouse model, Farrell and colleagues from the laboratory of Ivan Soltesz, Ph.D., at Stanford University began exploring another, little-known neuronal activity pattern: synchronized spikes of firing in the dentate gyrus, part of the hippocampus. These spikes, they found, occur when an "offline" brain is aroused. They may help us quickly process new information and orient ourselves to what's happening in our environment.

But dentate spikes also seem to promote associative memory—in which a sensory stimulus (say, a series of loud beeps) is stored as a memory, so that we come to associate the noise with a smoke alarm going off and the possible need to evacuate.

Sharp-wave ripples and dentate spikes may have complementary roles, Farrell says, "The brain is toggling through these two states."

This new knowledge about dentate spikes could open windows into some neuropsychiatric disorders. Perhaps dentate spikes affect attention and arousal in people with attention-deficit/hyperactivity disorder or post-traumatic stress disorder. Or maybe they are altered in Alzheimer's disease, disrupting formation of new memories.

Farrell is most interested in epilepsy, which is marked by synchronized spikes of excessive neuron firing. He plans to investigate the role of dentate spikes by better understanding their basic mechanisms and then manipulating the neural networks that control dentate spikes in the brains of epileptic mice. He also hopes to extend the study to children with epilepsy, in collaboration with clinicians at Boston Children's.

"In people with epilepsy, the synchronous activity during dentate spikes could tip the brain into a pathological state," Farrell speculates. "The dentate spikes add an extra push to the system."

More information: Jordan Farrell, Neural and behavioural state switching during hippocampal dentate spikes, *Nature* (2024). DOI: 10.1038/s41586-024-07192-8. www.nature.com/articles/s41586-024-07192-8

Provided by Children's Hospital Boston

Exploring how the human brain stores and preserves information

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.

How The Brain Decides Which Memories To Keep And Which To Discard

We've known for some time now that during sleep, the brain undergoes a memory spring cleaning of sorts, during which thoughts collected during that day are either converted into long-term memories or discarded.
It makes sense that this brain cleanse would occur at night when the brain is idle, considering there's no way that even the enormous human brain could possibly have enough room for everything that we take in on a given day.

Until recently, researchers didn't understand the mechanism for how the brain chooses what to keep. But, in a study recently published in the journal *Science*, researchers have demonstrated for the first time that during the day the brain goes through a series of steps in an effort to tag certain memories to be stored that night.

How the Brain Stores Memories

Researchers found that when the brain is idle during the day, simultaneous waves of neurons come together in what's called sharp wave ripples that literally shout to the rest of the brain that this memory is important and needs to be tagged for storage later that evening.

While sharp wave ripples happen less often during the day, their role is crucial because at night a series of 2,000-4,000 sharp wave ripples occur, causing the brain to condense its collection of memories.

"Sharp wave ripples are a pattern that occurs in the hippocampus, and in the wake state, this is the pattern that selects what will be put in for permanent storage and what will be triaged," says lead study author György Buzsáki, the Biggs Professor of Neuroscience at the New York University School of Medicine.

These sharp wave ripples make up the "most synchronous pattern in the mammalian brain," and they occur when the brain is offline, either idling during the day or at night.

"It takes what's good about sharp wave ripples in the brain to the next level," says Jim Gnadt, co-lead of the Integrative and Quantitative Neuroscience Team for the NIH BRAIN Initiative, who was not involved in the study.

How Rest Impacts Memory Storage

It seems that the brain cuts up the experiences that happen druing our day and combines them with other experiences that also occurred. Parts are removed, and thoughts are condensed.

"Many parts of our waking experience are cut out and bound together with other experiences using this pattern in the hippocampus," says Buzsáki.

As part of the study, researchers allowed rodents to run through a maze many times and looked at their brains while they were doing it. They found that when the mice were at rest drinking sugar water, that was when the sharp wave ripples occurred. The longer the rodents stayed by the water cooler, the more sharp waves that occurred in the brain. After the animal went to sleep and there were multiple sharp waves over night, the maze run that was replayed the next day was the one that occurred just before their water cooler idle rest.

The Brain's Two Algorithms

It turns out that the brain has two modes or algorithms: an acquisition mode and a storage mode. It's not that the brain is at rest when we sleep, it's that it's storing what was tagged during the day. "Sharp wave ripples happen when we're not attentive, but they are as important as the active state," says Buzsáki.

That's part of the reason that breaks are so important to the brain functioning at a higher level. Going for a run or taking a coffee break is the best way to remember or learn something complicated. You have to be at rest in creative work in order to have the best results.

Gnadt says that this research takes the whole idea of how memory works to the next level. "It gives us a better idea of why during sleep the brain grabs onto certain memories and not others," he says. Our brains are constantly doing the work of collecting and storing and this is another tool in understanding the mechanism for how it all comes together.

Study hints at ways to generate new neurons in old brains

Most neurons in the human brain last a lifetime, and for good reason.

Intricate, long-term information is preserved in the complex structural relationships between their synapses. To lose the neurons would be to lose that critical information—that is, to forget.
Intriguingly, some new neurons are still produced in the adult brain by a population of cells called neural stem cells. As brains age, however, they become less and less adept at making these new neurons, a trend that can have devastating neurological consequences, not just for memory, but also for degenerative brain diseases such as Alzheimer's and Parkinson's and for recovery from stroke or other brain injury.

A new Stanford Medicine study, published Oct. 2 in *Nature*, sheds hopeful new light on how and why neural stem cells, the cells behind the generation of new neurons in the adult brain, become less active as brains age.

The research also suggests some intriguing next steps in addressing old neural stem cell passivity—or even stimulating neurogenesis, the production of new neurons, in younger brains in need of repair—by targeting newly identified pathways that could reactivate the stem cells.

Anne Brunet, Ph.D., professor of genetics, and her team used CRISPR platforms, molecular tools that allow scientists to precisely edit the genetic code of living cells, to conduct a genome-wide search for genes that, when knocked out, increase the activation of neural stem cells in cultured samples from old mice, but not from young ones.

"We first found 300 genes that had this ability— which is a lot," emphasized Brunet, the Michele and Timothy Barakett Endowed Professor. After narrowing the candidates down to 10, "one in particular caught our attention," Brunet said. "It was the gene for the glucose transporter known as the GLUT4 protein, suggesting that elevated glucose levels in and around old neural stem cells could be keeping those cells inactive."

Dynamic brains

There are parts of the brain, such as the hippocampus and the olfactory bulb, where many neurons have shorter lives, where they regularly expire and may be replaced by new ones, said Tyson Ruetz, Ph.D., a formal post-doctoral scholar in Brunet's lab and the lead author of the *Nature* paper.

"In these more dynamic parts of the brain, at least in young and healthy brains," he said, "new neurons are constantly being born and the more transient neurons are replaced by new ones."

Ruetz, now the scientific advisor and co-founder of ReneuBio, developed a way to test the newly identified genetic pathways in vivo, "where the results really count," Brunet said.

Ruetz took advantage of the distance between the part of the brain where the neural stem cells are activated, the subventricular zone, and the place the new cells proliferate and migrate to, the olfactory bulb, which is many millimeters away in a mouse brain.

By knocking out the glucose transporter genes in the former, waiting several weeks, then counting the number of new neurons in the olfactory bulb, the team demonstrated that knocking out the gene indeed had an activating and proliferative effect on neural stem cells, leading to a significant increase in new neuron production in living mice.

With the top intervention, they observed over two-fold increase in newborn neurons in old mice.

"It's allowing us to observe three key functions of the neural stem cells," Ruetz said. "First, we can tell they are proliferating. Second, we can see that they're migrating to the olfactory bulb, where they're supposed to be. And third, we can see they are forming new neurons in that site."

The same technique could also be applied to studies of brain damage, Ruetz said. "Neural stem cells in the subventricular zone are also in the business of repairing brain tissue damage from stroke or traumatic brain injury."

'A hopeful finding'

The glucose transporter connection "is a hopeful finding," Brunet said. For one, it suggests not only the possibility of designing pharmaceutical or genetic therapies to turn on new neuron growth in old or injured brains, but also the possibility of developing simpler behavioral interventions, such as a low carbohydrate diet that might adjust the amount of glucose taken up by old neural stem cells.

The researchers found other provocative pathways worthy of follow-up studies. Genes relating to primary cilia, parts of some brain cells that play a critical role in sensing and processing signals such as growth factors and neurotransmitters, also are associated with neural stem cell activation.

This finding reassured the team that their methodology was effective, partly because unrelated previous work had already discovered associations between cilia organization and neural stem cell function. It is also exciting because the association with the new leads about glucose transmission could point toward alternative avenues of treatment that might engage both pathways, Brunet said.

"There might be interesting crosstalk between the primary cilia—and their ability to influence stem cell quiescence, metabolism and function—and what we found in terms of glucose metabolism," she said.

"The next step," Brunet continued, "is to look more closely at what glucose restriction, as opposed to knocking out genes for glucose transport, does in living animals."

More information: Anne Brunet, CRISPR–Cas9 screens reveal regulators of ageing in neural stem cells, *Nature* (2024). DOI: 10.1038/s41586-024-07972-2. www.nature.com/articles/s41586-024-07972-2

Provided by Stanford University Medical Center

Super-detailed map of brain cells that keep us awake could improve our understanding of consciousness

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.

Related: Ultrasound treatment 'jump-started' the brains of 2 people in coma-like state

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.

What happens in our brains when we 'hear' our own thoughts?

If you've ever had an imaginary argument in your head, you may have "heard" two voices at once. Your own inner voice and that of the other person in the quarrel. You may even "hear" the other person's accent, or the timbre of their voice.

So what's happening in the brain when that inner monologue is running? How is it that you can "hear" your thoughts?
As it turns out, the brain undergoes similar processes when you're thinking words as when you're speaking out loud.

Inner monologues are thought to be a simulation of overt speech, said Hélène Loevenbruck, a senior neurolinguistics researcher and head of the language team in the Psychology and NeuroCognition Laboratory at CNRS, the national French research institute. When we're children, we're virtual sponges, soaking up new information from every angle. Children playing alone will often speak dialogue aloud, for instance between a toy truck and a stuffed animal. At around 5 to 7 years old, that verbalization moves inward, Loevenbruck said.
Related: Does everyone have an inner monologue?
Earlier studies have shown that the brain exhibits similar activity with inner speech as it does with verbalized speech. When study participants are asked to deliberately "speak" inside their heads while lying in a magnetic resonance imaging (MRI) machine, scientists can see parts of the brain that process auditory information activate as if the participant were actually hearing the words.
"Cerebral regions activated during inner speech are quite similar to those that are activated during overt speech during real speech," Loevenbruck told Live Science. Those regions include the left hemisphere frontal lobe and parietal lobe, which help in processing outward stimulation.

But when you're thinking of something like a fictional argument with another person, the brain goes one step further. During that inner argument, you're playing two roles: yourself, and the person you're arguing with. When you play yourself, the auditory centers on the left side of your brain activate, Loevenbruck said. But when you internally switch roles to play the person you're arguing with, "there's a sort of a shift of cerebral region activation to the right hemisphere," in the equivalent areas like the parietal lobe and frontal lobe, she continued. Seeing the situation from a different perspective, even if it's a perspective you're crafting in your head, shifts which brain regions are engaged.

Researchers have also observed this phenomenon when participants are asked to imagine movement, Leovenbruck continued. Dancers, for instance, use a different part of their brain to imagine themselves dancing versus someone else dancing, a study published in the August 2005 issue of the journal Cerebral Cortex found.
It's one thing to see those brain regions activate when a person is told to think something, but it's much less understood what happens in our brains when we let our minds wander, Leovenbruck said. Not all inner monologues are deliberate. Sometimes words or sentences just pop into your head, unprovoked.

This phenomenon might have something to do with the brain's "default mode network," (DMN) said Robert Chavez, a neuroscientist at the University of Oregon. The DMN is a network of areas in the brain that are active when it is not engaged in a specific task. The DMN is thought to be involved with aspects of internal thought, such as retrieving memories, imagining the future, or interoception — a sense or "feeling" of what's happening in your body, such as hunger or thirst.

"The default mode network seems to be more active when your mind is wandering," Chavez told Live Science. Because the default mode network involves planning for the future by pulling from memories, recent experiences, and mental associations, it's thought that this combination of activities gives rise to an internal monologue while you focus inward.
A lot more research is needed to understand how inner thoughts arise spontaneously, Leovenbruck said. When taken to an extreme, inner thoughts can become dysfunctional, such as rumination after an uncomfortable or traumatic event, or in mental disorders, such as schizophrenia, in which people hear auditory hallucinations.

CAN WE EVER STOP THINKING

We often find ourselves in an endless thought loop. And every so often, we try to stop this endless flow of thoughts by telling ourselves to just stop thinking. But do we or can we ever really stop thinking?

It depends on how you define "thinking," said Michael Halassa, an assistant professor in the department of brain and cognitive sciences at MIT. A thought, which is the result of chemical firing between brain cells, can happen both on the conscious and unconscious level, he said.

The type of thinking we are aware of, such as the endless thoughts that pop up when we're trying to sleep, can, in theory, be silenced. That's presumably what meditation is all about, Halassa said.
But even though that's what meditators strive to do — it's not clear how much of a blank state they can actually achieve. "I don't know if [completely stopping thinking] is

theoretically possible and if it is, I think that would be incredibly difficult to test," said Julia Kam, a cognitive scientist at the Knight Lab at the University of California, Berkeley.

But it's clear that "meditators are a lot more tuned into what their thoughts are," Kam told Live Science. "So when they're supposed to be focused on something and their mind shifts away, then they're just a lot better at picking up on that shifting of attention."

There's a difference between having a thought, and being aware that you're having a thought, she said. So if you ask someone what they're thinking about and they respond with "nothing," they could just not be aware that they're having thoughts, Kam said. For instance, you could be deeply in thought about a relationship or an upcoming test, and you only become aware of it when someone taps you on the shoulder and snaps you out of it, she said. People who are thinking about "nothing" could also be having stream of consciousness thoughts that don't tell a coherent story, Halassa said.
But the brain never actually stops "thinking" in a broader sense. Most thoughts are actually happening in the background without us being aware of them, and "there's not really a way to turn these things off," Halassa told Live Science.

If you see a familiar face in a crowd and think you know them, you might not be able to come up with how you know them right away, Halassa said. But maybe hours later, you'll suddenly remember. That's a result of your brain "thinking," in the background, he said.

Even making decisions happens mostly unconsciously. For example, some of this background "thinking" results in what we call a "gut feeling," Halassa said. "A lot of times our brains are crunching a lot of numbers and spitting out a gut feeling that we ultimately go with." We don't always have conscious access to our brain's decision-making process and sometimes we create a story to explain the decision — sometimes it's accurate, sometimes it's not, he added.
Kam agrees that how you define "thinking," changes the answer to the question. "If you mean thinking, as in having an inner dialogue with ourselves, then, yes, we can stop having that inner dialogue," Kam said. But if thinking means not focusing attention on anything in particular, "I think that would be a lot more difficult for the layperson."

Even sitting here reading this, thinking about thinking is sending messages across a chain of neurons in the brain. So if we somehow manage to stop ourselves from "thinking" consciously, or achieve a "blank state of mind" through meditation, the brain won't sign off. It will continue to have thoughts — we just won't be aware of them.

Why Do Our Brains Have Folds?

Most of us have long accepted that our brains look like overgrown, shriveled walnuts. But why do our brains have those telltale wrinkles?

The cortex, or the outer surface of the brain — what's colloquially referred to as "gray matter" — expands and subsequently folds as our brains develop in the womb, said Lisa Ronan, a research fellow in the Department of Psychiatry at the University of Cambridge in England.
In essence, this expansion causes pressure to increase in that outer surface, which is then mitigated by folding, Ronan, told Live Science. [What If Humans Were Twice as Intelligent?]
Basically, imagine pushing at either end of a piece of rubber — at some point, the surface will bend in response to the increasing pressure. Or, if you're into geology, think of it like two tectonic plates crashing into each other: The pressure during the collision eventually becomes so great that those plates experience a geological fold.

These countless folds allow humans to pack in more neurons which, in turn, can mean more advanced brains with increased cognitive abilities, Ronan said.
However, folded brains are hardly ubiquitous, as most animals' brains aren't folded. For instance, the cortex of mice and rats does not expand enough during development to lead to folding, meaning their brains are wholly smooth surfaces.
When brain folding does happen, it tends to occur in animals with larger brains, Ronan told Live Science in an email. "But this isn't always the case — some large mammals like the manatee have far fewer folds than researchers would otherwise expect based on the size of their brain," she said.

There's a good reason for this: whether a fold forms depends not only on the overall growth of the cortex, but also the physical properties of that part of the cortex. For example, thinner regions tend to fold more easily than others, Ronan said.
"You're born with a folded brain," said Ronan. "But a key and intriguing point of gyrification [the study of cortical folding] is that the brain folds in specific patterns."

Though the brains' ridges and valleys — called gyri and sulci, respectively — look random, they're actually consistent across individuals, and even some species. Ronan said this consistency is important because it indicates that the folding has meaning.

Ultimately, the physical properties and unique folding patterns of each cortex region are linked to its function.

"Having the largest surface area in and of itself isn't enough; it's also about cortex function," Ronan said. "Elephants have way larger, and more folded, brains than humans do. But obviously, we're at the top of the evolutionary tree, and they're not."
In other words, the function of our cortex is more advanced, at least in some respects, than the function of the elephant cortex, even though the elephant's brain has more wrinkles.

So, those wrinkles that make our brains look like raisins are ultimately useful; they help us pack a bigger cerebral punch in the same amount of skull space.

Fascinating Insights into the Workings of the Human Brain

The human brain is a complex and fascinating organ. It controls everything we do, think, and feel. Understanding how it works can give us insights into our behavior, emotions, and health. Here are 17 intriguing facts about the brain that highlight its amazing functions and capabilities.

The Brain's Storage Capacity

The human brain can store an enormous amount of information. Scientists estimate it can hold around 2.5 petabytes of data. That's like having 3 million hours of TV shows stored in your head. This immense capacity shows how powerful our memory can be.

Neurons and Synapses

The brain contains about 86 billion neurons. These neurons connect through synapses, which transmit signals. Each neuron can connect with thousands of others, creating a vast network. This network is essential for all brain functions, from thinking to moving.

Brain Plasticity

Our brains are incredibly adaptable. This ability is known as plasticity. It means the brain can change and reorganize itself in response to new experiences. For example, if one part of the brain is damaged, another part can sometimes take over its functions. This adaptability helps us learn and recover from injuries.

Sleep and Brain Function

Sleep is vital for brain health. During sleep, the brain consolidates memories and clears out waste products. Poor sleep can lead to problems with memory, concentration, and mood. That’s why getting enough rest is crucial for maintaining cognitive function.

Emotional Regulation

The brain plays a key role in managing emotions. The limbic system, which includes structures like the amygdala and hippocampus, is crucial for this. It helps us process and respond to emotional experiences. Understanding this can help us manage our emotions better.

The Brain’s Energy Use

The brain is a very energy-demanding organ. It uses about 20% of the body’s total energy, even though it only makes up 2% of body weight. This high energy use supports all its complex activities, from thinking to controlling bodily functions.

Left and Right Hemispheres

The brain is divided into two hemispheres, each responsible for different functions. The left hemisphere is often associated with logical thinking and language, while the right is linked to creativity and spatial abilities. Both sides work together to perform most tasks.

Memory Formation

Memory formation involves multiple brain regions. The hippocampus is critical for creating new memories. Meanwhile, the cortex stores long-term memories. Understanding these processes can help improve memory techniques and treatments for memory-related conditions.

Impact of Stress

Chronic stress can harm the brain. It can shrink the hippocampus, impairing memory and learning. Stress also affects the amygdala, heightening fear and anxiety responses. Managing stress is important for protecting brain health.

Brain Development

The brain continues to develop into early adulthood. During childhood and adolescence, it undergoes significant changes. These changes impact behavior, decision-making, and risk-taking. Knowing this can help in understanding and supporting young people’s development.

Influence of Diet

What we eat affects our brain. Diets rich in fruits, vegetables, and omega-3 fatty acids support brain health. Conversely, high sugar and saturated fat intake can impair cognitive functions. Healthy eating is beneficial for maintaining mental sharpness.

Exercise and the Brain

Physical activity boosts brain function. Exercise increases blood flow to the brain and promotes the growth of new neurons. It also improves mood and reduces stress. Regular exercise is a great way to enhance cognitive health.

The Gut-Brain Connection

The brain and gut are closely connected. The gut microbiome influences brain function and mood. For example, certain gut bacteria can produce neurotransmitters like serotonin. This connection highlights the importance of gut health for overall well-being.

Language Processing

The brain has specialized areas for language. The Broca's area is involved in speech production, while the Wernicke's area is crucial for understanding language. Damage to these areas can result in language impairments, demonstrating their importance.

Social Interaction

Social interactions are vital for brain health. Engaging with others stimulates the brain and can improve cognitive functions. Social activities also reduce the risk of mental decline. Staying socially active is beneficial for maintaining a healthy brain.

Music and the Brain

Listening to music activates multiple brain regions. It can enhance mood, reduce stress, and even improve memory. Playing an instrument also has cognitive benefits, such as enhancing coordination and concentration. Music is a powerful tool for brain health.

Brain Aging

As we age, the brain undergoes changes. Some cognitive functions may decline, but others, like vocabulary and wisdom, can improve. Keeping the brain active through learning and social activities can help maintain cognitive health in older adults.

A Quick Guide to Brain Basics: From Parts of the Brain to Memory

The brain is our body's command center, the control tower for our body and mind—no wonder it's the focus of intense research across the globe, with so much interest in figuring out the mysteries of its inner workings, as well as what can be done to stave off cognitive decline.

According to the *British Medical Journal*, there are at least three levels of brain function: The brain controls movement and deciphers input from our senses, it manages our cognitive and emotional processes, and it maintains social cognition and behavior.

"The brain is like a supercomputer," says neuroscientist Tara Tracy, Ph.D., assistant professor and a specialist in neurological decline at the Buck Institute. "And the circuits within the supercomputer are the neurons in the brain."

Neurons are nerve cells; there are about 100 billion neurons in the brain of an adult, "and they're not all the same," says Tracy. "There are all sorts of neurons that do different things. Neurons process all the information for us. They help us have cognition, the ability to make decisions, the ability to remember things." All of your thoughts, the sensations you feel, the movements you make, your emotions and memories—they all stem from signals that are sent through neurons.

Inside the brain

"For daily living, there are different types of neurons," says Tracy. "There are specific neurons that are important for our movement, neurons that are important for functions like dealing with anxiety or stress. There are neurons that are important for memory and remembering things, and neurons that are important for encoding information from the sensory system—what we see or smell or hear.

"You put all these together, and it's very complicated," she continues, "but all of these different neurons come together in the brain and can function together as this big supercomputer, to integrate all this information and allow us to do things. That's one of the most fascinating things about the brain, that it can be so complex but it all happens at the same time—because neurons are also very fast. They transmit information very, very quickly, at the millisecond level."

That speed is important to consider, because we know that some of our behaviors and habits can make the system operate more sluggishly. And there are many advantages to having neural communication that's operating at an optimal level.

"Let's say you trip and fall," says Tracy. "You can respond to that quickly if your neurons are really fast, if the connections are well made within the brain and the communication between the neurons is fast." Meaning, you'll have an easier time righting your balance before you face plant on the sidewalk. "So that's an important property of neurons in the brain, that they can do things very quickly," she says. "And they're structured, and the system is set up, in a way that helps you accomplish things to the best way possible—meaning to protect yourself from potential dangers."

The importance of connections

When it comes to the workings of the brain, so much is still not understood. The signals are sent from neuron to neuron along various pathways, and neuroscientists have a lot of those pathways worked out, Tracy points out. "The visual system, for example, is fairly well understood, in terms of the neurons that go from your eyes into your brain and where in the brain they're connected, and how they then process the visual information," she says. "There are a number of pathways that neuroscientists do have a pretty good understanding of—but not every pathway."

Memory isn't completely understood, she explains. "When you first form a memory, we kind of know where that happens in the brain. But the long-term storage of a memory—like when you remember something that happened 20 years ago—the pathways of how that information gets stored, and where, are not well understood."

Depending on what information is being processed, it gets processed in different parts of the brain, and those different sections all work together. Three important areas: The **cerebellum** is in charge of movement; when you're out there on the pickleball court, or are learning how to play the guitar, that's the area of the brain that's activated. The **cerebrum** is what allows conscious thoughts, plans, imagination, reading, recognizing people you know, and so much more. The **cerebral cortex** is where most of the brain's information-processing takes place.

An elaborate, brilliant machine—brought to us via evolution, many neuroscientists believe, says Tracy. "We believe that we've evolved the abilities to manage the things we do in daily life, because our brain evolved with this structure, these connections and neurons."

A smooth-working noggin

Brain health, then, is when all of these are clicking along well. And though much of the mechanisms that cause various brain dysfunctions are a puzzle, there's growing research that underlines the importance of taking steps to protect your brain health: challenging your mind, eating a healthy diet, being socially active, prioritizing sleep, taking care of your heart, and—perhaps especially important—emphasizing exercise.

"I think most scientists think that exercise is super-important," says Tracy. "Lack of exercise in general can have a bad effect on the brain. We don't really understand why—there's been a lot of work on this, and scientists have ideas about it, but research has shown that people who do a lot of exercise are associated with having good brain health."

So lace up your sneakers, find ways to destress, make sleep a priority, eat foods that are best for your brain and heart. It's worth doing whatever we can, because good brain health is the bottom line goal—so that this magnificent machine, this intricate supercomputer, can keep us functioning at our very best, for as many years as possible.

Exploring the brain's survival mechanisms

The human brain, an intricate organ, is hardwired for survival. It's the command center for the nervous system, receiving signals from the body's sensory organs and outputting information to the muscles. The brain is responsible for our thoughts, feelings, memory storage, and general perception of the world. But the brain is not just concerned with physical survival.
The brain's primary function is to ensure our survival. It's responsible for everything that keeps us alive, from regulating our breathing and heartbeat to controlling our body temperature. It's also responsible for our fight-or-flight response—a physiological reaction that occurs in response to a perceived harmful event, attack, or threat to survival. This response prepares the body to fight or flee the danger.

However, the brain's role in survival extends beyond the physical. It's also responsible for our psychological survival. This is where the ego comes into play.

The ego's role in psychological survival

The ego, a part of our mind that mediates between the conscious and the unconscious, is also hardwired for survival. Unlike the brain, which is concerned with physical survival, the ego is concerned with psychological survival. It's designed to protect us against mental and emotional pain.

The ego creates a sense of self, a personal identity we use to navigate the world. It helps us make sense of our experiences and gives us a sense of control and predictability. However, the ego also creates a sense of separation from others and the world around us. This separation can lead to feelings of isolation, fear, and insecurity.

The ego creates defenses to protect us from these negative feelings. These defenses can take many forms, from denial and repression to projection and rationalization. They shield us from the mental and emotional pain that can come from confronting our fears, insecurities, and vulnerabilities.

The illusion of safety versus the pursuit of freedom

The ego's defenses create an illusion of safety. They make us feel secure and in control. However, this safety is just an illusion. A false sense of security keeps us trapped in our comfort zones and prevents us from growing and evolving.

On the other hand, there is freedom. Freedom is the ability to live authentically, be true to ourselves, and express ourselves fully. It's the ability to face our fears, insecurities, and vulnerabilities head-on and embrace them as part of who we are.

However, freedom comes with its own set of challenges. It requires courage, resilience, and a willingness to step out of our comfort zones. It requires us to let go of the ego's defenses and to confront the mental and emotional pain that we have been avoiding.

Surviving or truly living: the choice is yours

Ultimately, the fundamental choice we all have to make is whether we want to live with the illusion of safety or freedom? Do we merely want to survive, or do we want to live?

Survival, whether physical or psychological, is essential. However, survival is not the same as living. Living involves growth, evolution, and the pursuit of freedom. It involves stepping out of our comfort zones, confronting our fears, insecurities, and vulnerabilities, and embracing them as part of who we are.

So, the question remains: do you merely want to survive, or do you want to live? The choice is yours. It's a choice between the illusion of safety and the pursuit of freedom. It's a choice between merely surviving and truly living.

Frequently Asked Questions

Q. What is the primary function of the human brain?

The primary function of the human brain is to ensure our survival. It's responsible for everything that keeps us alive, from regulating our breathing and heartbeat to controlling our body temperature. It's also responsible for our fight-or-flight response—a physiological reaction that occurs in response to a perceived harmful event, attack, or threat to survival.

Q. What is the role of the ego in psychological survival?

The ego, a part of our mind that mediates between the conscious and the unconscious, is also hardwired for survival. Unlike the brain, which is concerned with physical survival, the ego is concerned with psychological survival. It's designed to protect us against mental and emotional pain.

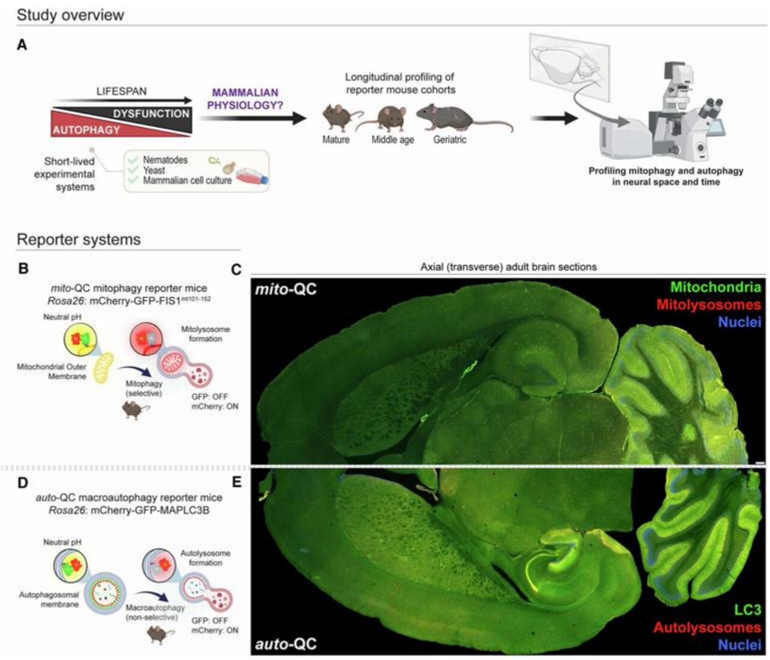
Q. What is the difference between the illusion of safety and the pursuit of freedom?

The ego's defenses create an illusion of safety. They make us feel secure and in control. However, this safety is just an illusion. A false sense of security keeps us trapped in our comfort zones and prevents us from growing and evolving. On the other hand, freedom is the ability to live authentically, to be true to ourselves, and to express ourselves fully. It's the ability to face our fears, insecurities, and vulnerabilities head-on and to embrace them as part of who we are.

Q. What is the difference between surviving and truly living?

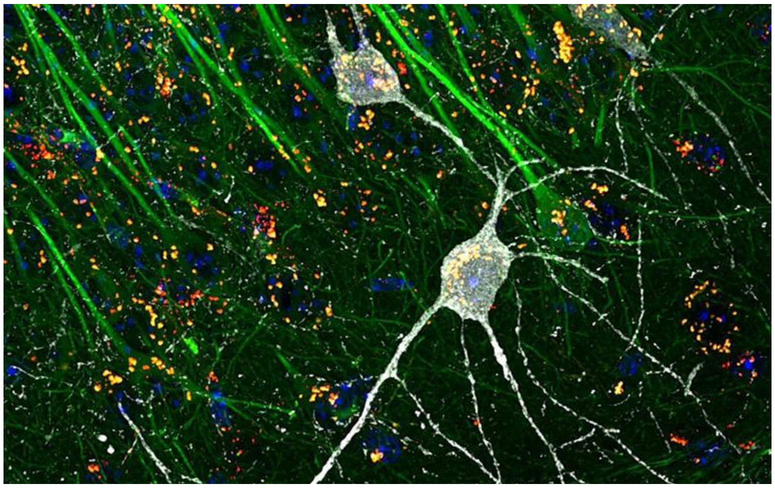
Survival, whether physical or psychological, is essential. However, survival is not the same as living. Living involves growth, evolution, and the pursuit of freedom. It involves stepping out of our comfort zones, confronting our fears, insecurities, and vulnerabilities, and embracing them as part of who we are.

How cells recycle damaged mitochondria in middle age may be critical for brain health



Mapping longitudinal changes in mitophagy and macroautophagy in the aging mammalian brain. Credit: The EMBO Journal (2024). DOI: 10.1038/s44318-024-00241-y

Mitochondria play an essential role in maintaining cellular health. When damaged, they are removed through a recycling process called mitophagy, which is crucial for the function of long-lived cells, especially in the brain. Impaired mitophagy has been strongly associated with neurodegenerative disorders like Alzheimer's and Parkinson's disease, making it a critical focus for drug discovery and therapeutic innovation.


Snapshot of a specialized nerve cell, called an interneuron, undergoing autophagy in the hippocampus—a key brain region for memory function. Credit: Anna Rappe

New research from the McWilliams Lab at the University of Helsinki, spearheaded by doctoral researcher Anna Rappe, MSc, reveals a changing and unexpected landscape of mitophagy across in different brain cell types during the aging process. The research is published in *The EMBO Journal*.

For example, mitophagy levels increased in a specialized mouse brain region responsible for movement as the animals aged, while in memory-related brain cells, mitophagy first rose and then sharply declined in old age. These findings identify midlife as a key inflection point for healthy brain aging, offering novel insights into the molecular mechanisms that sustain mammalian brain function.

Another key finding of the study was that some lysosomes, the structures responsible for breaking down cellular waste, lose acidity as the brain ages. This exciting observation parallels changes observed in Alzheimer's disease models, suggesting that the processes seen in normal aging might be exacerbated in the development of neurodegenerative conditions.

The results challenge previous assumptions that mitophagy simply decreases with age across all species, showing that in longer-lived mammals, this special recycling process is much more dynamic and complex.

Previous studies, often using short-lived models like yeast and worms, suggested that mitophagy levels decline over a lifetime, marking it as a hallmark of aging. However, studying this process in the aging mammalian brain has been challenging due to the complexity of brain tissue and the limitations of traditional research methods.

Only recently have the tools needed to track mitophagy across different tissues and organs in mammals become available. The McWilliams Lab employed cutting-edge tools in mouse genetics, optobiology, neuroscience, and advanced imaging to track mitophagy over time in different brain cell types.

Their results highlight the importance of developing new perspectives when studying brain aging in longer-lived species, with midlife emerging as a critical period for preserving brain function.

Implications for understanding brain aging in health and disease

Associate Professor Thomas McWilliams, who supervised the study, contextualized these findings, "There is no doubt that mitophagy decreases in shorter-lived species. While we share important genes and mechanisms, the tissues of longer-lived mammals have evolved under distinct pressures to handle different challenges. Our work reveals that mitophagy is highly dynamic in the aging mouse brain and suggests midlife is a crucial period for mammalian brain health."

He added that while the field has made progress in understanding neurodegenerative diseases, the high failure rate of current therapies underscores the need for new approaches.

"There is still much to do, but we are excited by these new findings that reshape our understanding of brain aging. Together with our clinical collaborators, we are committed to advancing this research towards more human-centered applications. We hope our current results will give companies and translational researchers a valuable roadmap to help accelerate the development of new therapies for brain disease."

More information: Anna Rappe et al, Longitudinal autophagy profiling of the mammalian brain reveals sustained mitophagy throughout healthy aging, *The EMBO Journal* (2024). DOI: 10.1038/s44318-024-00241-y

Provided by University of Helsinki

Scientists Just Discovered That Some Memories Don't Live in Our Brains

- The process of memory is often tied to the brain, but a new study reveals that other cells outside our skulls contain their own kind of "body memory."
- In a new study, scientists also discovered that these memory genes acted similarly to neurons in that they more effectively "learned" through spaced-out repetition rather than just one giant cram session.
- Gaining a deeper understanding of this "body memory" could help scientists and clinicians create new ways to address diseases and other maladies.

Memory—and by extension, learning—is central to life on Earth and its greatest intellectual byproduct: the scientific method. The ability to test hypotheses, draw on past experience, and develop new ways of thinking lies at the cornerstone of our modern society. Our language often describes this process as a purely cerebral pursuit. After all, the smartest among us are often labeled "brainiacs," but a new study suggests that the ability to learn *isn't* exclusive to the brain.

A team of researchers at New York University (NYU) set out to determine if other cells in the body, in this case kidney and nerve cells, could store memory like neurons. This isn't the same as, say, recalling specific moments in your life, but instead memories of specific patterns to help perform their life-sustaining functions. What they found is that other cells do contain a sense of a memory and also follow a specific neurological property known as the massed-spaced effect. The results of the study were published in the journal *Nature Communications*.

"This discovery opens new doors for understanding how memory works and could lead to better ways to enhance learning and treat memory problems," NYU's Nikolay Kukushkin, a co-author of the study, said in a press statement. "At the same time, it suggests that in the future, we will need to treat our body more like the brain—for example, consider what our pancreas remembers about the pattern of our past meals to maintain healthy levels of blood glucose or consider what a cancer cell remembers about the pattern of chemotherapy."

In 1885 German psychologist Hermann Ebbinghaus detailed the idea of "spaced repetition," or massed-spaced effect, in his book *Memory: A Contribution to Experimental Psychology*. This refers to the idea that the best method of learning is through repeated, spaced study sessions rather than massed presentation (or what's commonly known across high school and college campuses as "cramming.") Kukushkin and his team focused on these two types of learning in cells by introducing different patterns of chemical signals, which essentially mimicked brain cells as they're exposed to patterns of neurotransmitters. To study this memory-making effect, the scientists developed the cells with a protein that glowed when the "memory gene" was activated.

The scientists noticed that when the chemical patterns were introduced in space-out intervals, the "memory gene" turned on more strongly and for longer intervals than when exposed to a prolonged exposure.

"This reflects the massed-space effect in action," Kukushkin said in a press statement. "It shows that the ability to learn from spaced repetition isn't unique to brain cells, but, in fact, might be a fundamental property of all cells."

Writing for *Psychology Today*, Kukushkin also notes that this "body memory" could play a profound role in health and disease while also providing powerful evidence of the power of repeated learning, which can strengthen memory instead of slowly losing useful information to Ebbinghaus' "forgetting curve."

So if you've got a big test coming up, it's biologically advantageous to hit books early *and* often rather than slogging through a sleepless night of cramming.

What Happens to Your Brain When You Meditate Every Day?

Improved memory, attention, and learning? Yes, please!

People who meditate regularly swear by it, but others are often skeptical of it, thinking it's a little, you know, woo-woo.

But what if we told you that meditation is actually a powerful way to train your brain to be calmer and sharper? That scientific studies have shown that meditating regularly can alter brain shape, size, and function?

"Meditation can actually create structural changes in the brain. It has been shown to increase gray matter in the brain, particularly in areas related to learning, memory, emotion regulation, and perspective," says Mirela Loftus, MD, PhD, medical director at Newport Healthcare.

Based on the amount of scientific evidence supporting meditation, every doctor would be prescribing it if it were a pill, says Gary Soffer, MD, an integrative medicine specialist at Yale Medicine.

Let's dive in and take a look at what meditating regularly does to your brain.

At a Glance

Meditating regularly changes the brain in several ways. It alters brain waves, increases gray matter, and improves connectivity within the brain. The cherry on top? It also boosts feel-good chemicals like dopamine and serotonin.

Together, these changes make us happier, calmer, and sharper. As a result, we're better equipped to handle stress, stay focused on tasks, and experience a greater sense of well-being in our daily lives.

What Meditating Every Day Does to Your Brain

While meditation is an ancient practice, science is still unlocking the full spectrum of its benefits. A surge in research over the past few decades has investigated meditation's effects on both the brain and body.

Electroencephalography (EEG) and structural/functional magnetic resonance imaging (MRI) techniques have been used to map the brain and study the effects of meditation on the brain.

Increases Gray Matter

Meditation increases gray matter in the brain, particularly in areas related to learning, memory, emotion regulation, and perspective, says Dr. Loftus. In fact, imaging studies show that meditation increases the size and volume of the brain, due to increased gray matter concentration.

Strengthens the Prefrontal Cortex

Regular meditation is linked to increased thickness of the prefrontal cortex, which is associated with higher-order brain functions such as awareness, concentration, memory, and decision-making, Dr. Loftus explains.

MRI scans have found that in addition to increasing the gray matter in the prefrontal cortex, meditation also improves the neural connectivity and cognitive function in this area.

Improves Neuroplasticity

Neuroplasticity is the brain's ability to change and rewire itself based on new information and experiences. Meditation increases neuroplasticity by improving neural connectivity patterns across different regions of the brain.

By enhancing connectivity between different brain regions, meditation can improve cognitive functions, information processing, and emotional regulation, says Dr. Loftus.

Boosts Dopamine and Serotonin

Dopamine and serotonin are neurotransmitters, or chemical messengers in the brain. Meditation is linked to a larger quantity of positive neurotransmitters like serotonin and dopamine in the brain, says Dr. Soffer.

Apart from regulating functions like sleep, growth, and metabolism, these chemicals play an important role in maintaining our emotional equilibrium, by making us feel positive and happy.

Alters Brain Waves

Meditation not only calms our blood pressure, respiratory rate, and heart rate, it also alters our brain waves. This helps us relax, concentrate, and process information better.

Those who practice meditation regularly often exhibit higher levels of gamma brain waves, which are associated with heightened perception, problem-solving, and consciousness, says Dr. Loftus.

Decreases the Size of the Amygdala

The amygdala, which is responsible for the fight-or-flight response, tends to shrink in people who meditate regularly, says Dr. Loftus. Research shows that this significantly reduces our stress levels.

Benefits of Meditation

As a result of these changes in the brain, meditation offers us several mental, emotional, and cognitive benefits. Research shows us that it can improve:

- Mood
- Emotional regulation
- Self-awareness
- Attention
- Concentration
- Memory
- Spatial abilities
- Execution function (thinking, planning, decision-making)

- Conflict resolution
- Mindfulness
- Relaxation
- Self-compassion
- Stress
- Sleep
- Pain
- Anxiety
- Depression
- Insomnia
- Post-traumatic stress disorder (PTSD)

Mindful Moment

Need a breather? Take this free 3-minute meditation to calm down quickly—or choose from our guided meditation library to find another one that will help you feel your best.

How to Meditate Every Day

The best way to reap the benefits of meditation is to incorporate it into your daily routine and practice it every day. The benefits can be vast if you stick to the practice, says Dr. Soffer.

Here's how you can make daily meditation a habit:

- **Start small:** You can start with just a few minutes every day. Even five minutes of meditation can be helpful. As you get more comfortable with it, you can work your way up to longer sessions.

- **Find a time that works for you:** Choose a specific time of day that works best for you, whether it's first thing in the morning, during your lunch break, or before bed. Consistency helps in forming a habit.
- **Pick a quiet spot:** Choose a place where you can sit comfortably and won't be interrupted. It could be a swing on your porch, a cozy chair in your room, or even a quiet corner in your office.
- **Set the ambience:** If you like, you can set the ambience for your meditation session by dimming the lights, playing gentle soothing music, and lighting a scented candle.
- **Set an intention:** Before you start meditating, set a clear intention or goal for your practice. It could be to reduce stress, increase focus, or simply take a break from your busy day.
- **Use a guided meditation program:** If you're new to meditating and not sure how to go about it, it can be easier to start with a guided meditation program that takes you through the steps. There are several free programs available online—you can choose the one that best fits your needs and your schedule.
- **Focus on your breath:** Use your breath to anchor you to the present. If your mind wanders to other things, gently bring your focus back to your breath.
- **Reflect on the practice:** After you finish, take a moment to reflect on your session. What did you feel and learn? If you like, you can write down your thoughts in a journal.
- **Be patient with yourself:** Building a new habit takes time. Be patient with yourself on this journey. Don't get frustrated if your mind wanders or if you miss a day. Some days will be easier and others will be harder.

Related: The 7 Best Meditation Apps of 2024

Sample Meditations to Try

If you want to get started with meditation, these are a few types you can try.

Breath Awareness Meditation

Breath awareness meditation simply involves focusing your attention on your breath. Here's how to do it:

- Sit comfortably and close your eyes.
- Taking deep breaths, bring your attention to your breath. Pay attention to the way the air comes in through your nose, fills up your stomach, and goes out again.
- If your attention wanders, gently bring it back to your breath.
- Do this for as long as you like. When you're done, open your eyes slowly.

Body Scan Meditation

Body scan meditation involves bringing your attention to each part of your body and consciously relaxing it, one at a time. Here's how to do it:

- Lie down on your back and close your eyes.
- Bring your attention to your toes, breathing into them and relaxing them. Notice any sensations you feel without trying to change anything.
- Slowly move your focus to your feet, ankles, calves, knees, thighs, and so on, up to the top of your head.
- After you finish scanning your entire body, take a few deep breaths and open your eyes.

Loving-Kindness Meditation

Loving-kindness meditation involves sending kind thoughts to yourself, your loved ones, and the world around you. Here's how to do it:

- Get comfortable, close your eyes, and take a few deep breaths.
- Send kindness to yourself. You can repeat silently, "May I be happy. May I be healthy. May I be safe."
- Extend kindness to your loved ones. Think of someone you love and repeat, "May you be happy. May you be healthy. May you be safe."
- Expand kindness to others. Gradually extend these wishes to a neutral person, someone you have difficulty with, and finally to all living beings.

Walking Meditation

If you find sitting still difficult and prefer movement, walking meditation may be for you. Here's how to do it:

- Find a quiet space to walk comfortably back and forth.
- Walk slowly, paying attention to the sensations in your feet as they make contact with the ground.
- Coordinate your breath with your steps, inhaling and exhaling with each step.
- Notice any thoughts that come to you, letting them go and returning your focus to walking.
- Turn around and continue walking mindfully when you reach the end of your space.

- When you’re done, stand still, take a few deep breaths, and reflect on the experience.

Related: How to Practice Music Meditation

Key Takeaways

While meditation may seem simple on the surface, its impact on the brain is quite profound. Incorporating it into your daily routine can improve your attention, memory, mood, and stress levels. You can start slowly with just a few minutes a day, working your way up to longer sessions over time. Just do your best to be regular with it!

Neurons in The Brain Appear to Follow a Distinct Mathematical Pattern

Illustration of active neuron cells in a synapse network© Provided by ScienceAlert

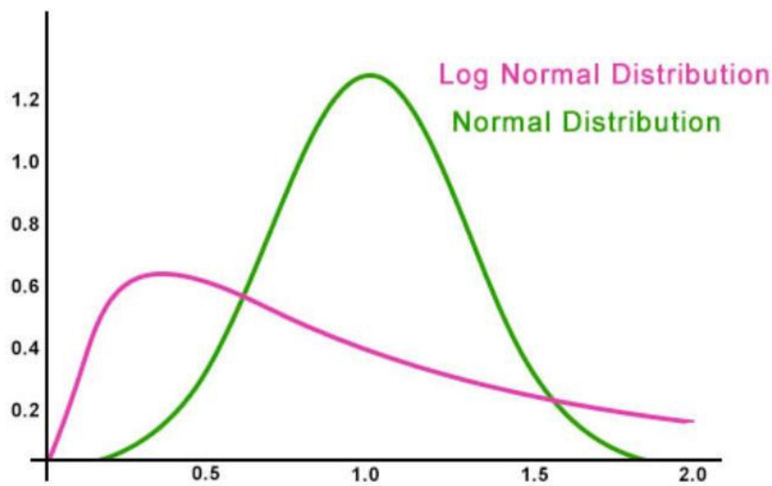
Researchers taking part in the Human Brain Project have identified a mathematical rule that governs the distribution of neurons in our brains.

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.

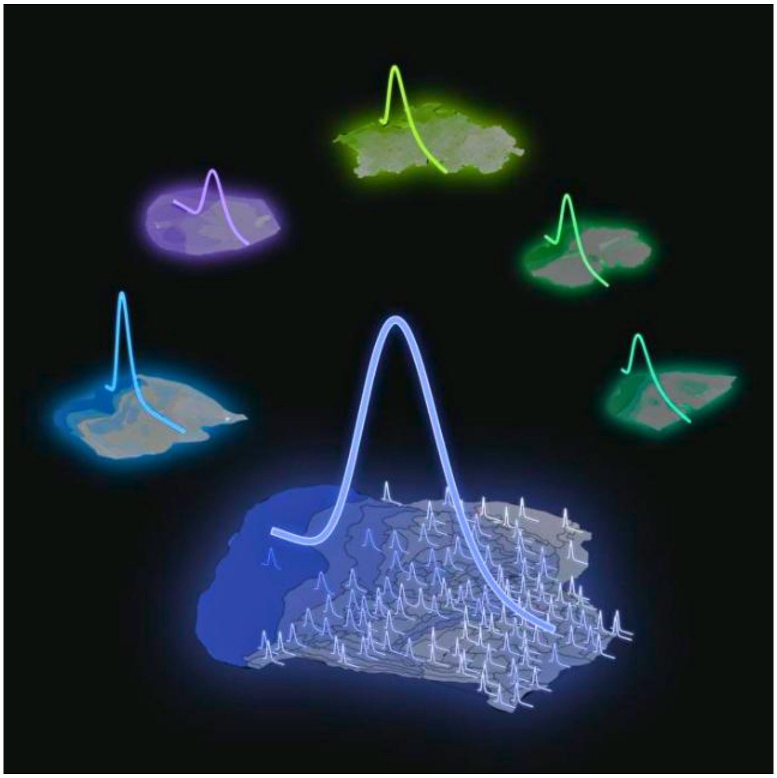
Brain structure and function depend on neuron numbers and arrangement. The density of neurons in different regions and layers of that outer tissue layer – the cerebral cortex – varies considerably.

"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.

The study has been published in *Cerebral Cortex*.

Alpha, beta, theta: What are brain states and brain waves? And can we control them?

Credit: Pixabay/CC0 Public Domain© Provided by Medical Xpress

There's no shortage of apps and technology that claim to shift the brain into a "theta" state—said to help with relaxation, inward focus and sleep.

But what exactly does it mean to change one's "mental state"? And is that even possible? For now, the evidence remains murky. But our understanding of the brain is growing exponentially as our methods of investigation improve.

Brain-measuring tech is evolving

Currently, no single approach to imaging or measuring brain activity gives us the whole picture. What we "see" in the brain depends on which tool we use to "look." There are myriad ways to do this, but each one comes with trade-offs.

We learnt a lot about brain activity in the 1980s thanks to the advent of magnetic resonance imaging (MRI).

Eventually we invented "functional MRI," which allows us to link brain activity with certain functions or behaviors in real time by measuring the brain's use of oxygenated blood during a task.

We can also measure electrical activity using EEG (electroencephalography). This can accurately measure the timing of brain waves as they occur, but isn't very accurate at identifying which specific areas of the brain they occur in.

Alternatively, we can measure the brain's response to magnetic stimulation. This is very accurate in terms of area and timing, but only as long as it's close to the surface.

What are brain states?

All of our simple and complex behaviors, as well as our cognition (thoughts) have a foundation in brain activity, or "neural activity." Neurons—the brain's nerve cells—communicate by a sequence of electrical impulses and chemical signals called "neurotransmitters."

Neurons are very greedy for fuel from the blood and require a lot of support from companion cells. Hence, a lot of measurement of the site, amount and timing of brain activity is done via measuring electrical activity, neurotransmitter levels or blood flow.

We can consider this activity at three levels. The first is a single-cell level, wherein individual neurons communicate. But measurement at this level is difficult (laboratory-based) and provides a limited picture.

As such, we rely more on measurements done on a network level, where a series of neurons or networks are activated. Or, we measure whole-of-brain activity patterns which can incorporate one or more so-called "brain states."

According to a recent definition, brain states are "recurring activity patterns distributed across the brain that emerge from physiological or cognitive processes." These states are functionally relevant, which means they are related to behavior.

Brain states involve the synchronization of different brain regions, something that's been most readily observed in animal models, usually rodents. Only now are we starting to see some evidence in human studies.

Various kinds of states

The most commonly-studied brain states in both rodents and humans are states of "arousal" and "resting." You can picture these as various levels of alertness.

Studies show environmental factors and activity influence our brain states. Activities or environments with high cognitive demands drive "attentional" brain states (so-called task-induced brain states) with increased connectivity. Examples of task-induced brain states include complex behaviors such as reward anticipation, mood, hunger and so on.

In contrast, a brain state such as "mind-wandering" seems to be divorced from one's environment and tasks. Dropping into daydreaming is, by definition, without connection to the real world.

We can't currently disentangle multiple "states" that exist in the brain at any given time and place. As mentioned earlier, this is because of the trade-offs that come with recording spatial (brain region) versus temporal (timing) brain activity.

Brain states vs. brain waves

Brain state work can be couched in terms such as alpha, delta and so forth. However, this is actually referring to brain waves which specifically come from measuring brain activity using EEG.

EEG picks up on changing electrical activity in the brain, which can be sorted into different frequencies (based on wavelength). Classically, these frequencies have had specific associations:

- gamma is linked with states or tasks that require more focused concentration
- beta is linked with higher anxiety and more active states, with attention often directed externally
- alpha is linked with being very relaxed, and passive attention (such as listening quietly but not engaging)
- theta is linked with deep relaxation and inward focus
- and delta is linked with deep sleep.

Brain wave patterns are used a lot to monitor sleep stages. When we fall asleep we go from drowsy, light attention that's easily roused (alpha), to being relaxed and no longer alert (theta), to being deeply asleep (delta).

Can we control our brain states?

The question on many people's minds is: can we judiciously and intentionally influence our brain states?

For now, it's likely too simplistic to suggest we can do this, as the actual mechanisms that influence brain states remain hard to detangle. Nonetheless, researchers are investigating everything from the use of drugs, to environmental cues, to practicing mindfulness, meditation and sensory manipulation.

Controversially, brain wave patterns are used in something called "neurofeedback" therapy. In these treatments, people are given feedback (such as visual or auditory) based on their brain wave activity and are then tasked with trying to maintain or change it. To stay in a required state they may be encouraged to control their thoughts, relax, or breathe in certain ways.

The applications of this work are predominantly around mental health, including for individuals who have experienced trauma, or who have difficulty self-regulating—which may manifest as poor attention or emotional turbulence.

However, although these techniques have intuitive appeal, they don't account for the issue of multiple brain states being present at any given time. Overall, clinical studies have been largely inconclusive, and proponents of neurofeedback therapy remain frustrated by a lack of orthodox support.

Other forms of neurofeedback are delivered by MRI-generated data. Participants engaging in mental tasks are given signals based on their neural activity, which they use to try and "up-regulate" (activate) regions of the brain involved in positive emotions. This could, for instance, be useful for helping people with depression.

Another potential method claimed to purportedly change brain states involves different sensory inputs. Binaural beats are perhaps the most popular example, wherein two different wavelengths of sound are played in each ear. But the evidence for such techniques is similarly mixed.

Treatments such as neurofeedback therapy are often very costly, and their success likely relies as much on the therapeutic relationship than the actual therapy.

On the bright side, there's no evidence these treatment do any harm—other than potentially delaying treatments which have been proven to be beneficial.

How your brain decides which memories to save

How your brain decides which memories to save© Provided by Fast Company

Most of what happens to you every day vanishes without a trace. Countless walks, interactions, meals, and discussions have little or no long-term impact on your brain. You will have no memory of many of the people you pass when you walk by them, or of particular words that someone spoke to you (even if you recall the gist of what they were saying).

What determines which events and interactions create memories? There are several ways to address this question, and they each lead to different perspectives on how to answer it.

The brain's economy

One approach to thinking about the memories the brain stores is based on economics. The currency of the realm in the brain is energy. The brain itself is an energy-hungry organ. It is 2% to 3% of your body weight, but uses 20% to 25% of your daily energy supply. That is the physiological cost of generating electrical signals, processing the variety of chemicals neurons use to communicate, and creating subtle changes in the growth of brain structures.

In general, the brain uses about the same amount of energy per hour regardless of what it is doing. That is, the overall energy cost associated with generating all that chemical and electrical activity is about the same whether you're thinking hard or mindlessly scrolling Instagram. That means that the brain is trying to minimize the amount of time that it devotes to any given task, because the more time you do something, the more energy the brain is allocating to that task.

Building a new memory has a physiological cost, because structures have to grow that influence the neurons in the pathway that is storing that memory to ensure that the pattern of brain activity associated with that memory can be created again.

Memories are more likely to be stored when the cost of creating the new connection is likely to reduce the amount of time the brain will have to spend doing something in the future. The brain is investing energy now to reduce future costs.

For example, if you have an important and deep conversation with a colleague, there is likely to be a future time savings to storing a memory of that conversation. When you see that colleague again, remembering that conversation will make the next discussion more efficient.

What kind of memory?

The word *memory* is inaccurate here. There are many different memory systems that the brain uses. The things we usually call memories are part of the *episodic memory* system, which stores memories of episodes of your life (like having a conversation with a colleague or going to the grocery store). You also have *procedural memories*, which are your memories of how to carry out a task like typing or tying your shoe. One other important memory system for your work life is *semantic memory*, which is your knowledge about what words and concepts mean.

All of these memory systems have the same basis in the brain's economy. You will create physiological changes if it is likely that this will save you time later. Your procedural memory develops habits so that you can perform actions more quickly. In contrast, your semantic memory system refines the meanings of concepts to make you faster at understanding situations and communicating with others. Finally, your episodic memory system stores information when those situations are likely to be important enough that you will need that information again in the future to navigate a similar situation.

It's important to keep these distinctions in mind, because you may not be able to recall a particular situation, but it still may have influenced your ability to carry out a procedure or it may have affected your knowledge of the world. So, just because you don't remember doing something later doesn't mean that it had no impact on any of your memory systems.

Desirable difficulty

One principle about memory that is valuable to know is the concept of the *desirable difficulty*, articulated by Bob Bjork and Elizabeth Bjork. You might wonder how the brain determines whether storing something is likely to make you faster at engaging with the world in the future. The brain uses the effort and engagement associated with an event as part of that calculation.

Both parts of the phrase *desirable difficulty* matter.

Let's think first about difficulty. When you engage in intense and productive thinking, then you spend a lot of time and focused attention on that work. Because of that effort, the brain calculates that storing the results of that work is likely to make you faster at dealing with similar information in the future. So, if you work hard to solve a problem, then remembering the solution to that problem later is probably going to allow you to deal with that situation more quickly when you encounter it again.

What makes a difficulty desirable is that the work is ultimately productive. That is, you think hard or work hard with a colleague, and feel like you're making progress. Storing a memory of that situation is likely to make life easier in the future. You have probably had situations, though, in which you encounter a problem so hard to solve or so far beyond your capacity that the engagement is frustrating rather than productive.

Frustration is an emotion that signals that your brain doesn't want to keep working on it, because you're wasting its precious energy on something that is not valuable. When you get frustrated in this way, you're not likely to store much of the information you were thinking about, because it's not likely to make you more efficient in the future.

Intensity of emotion

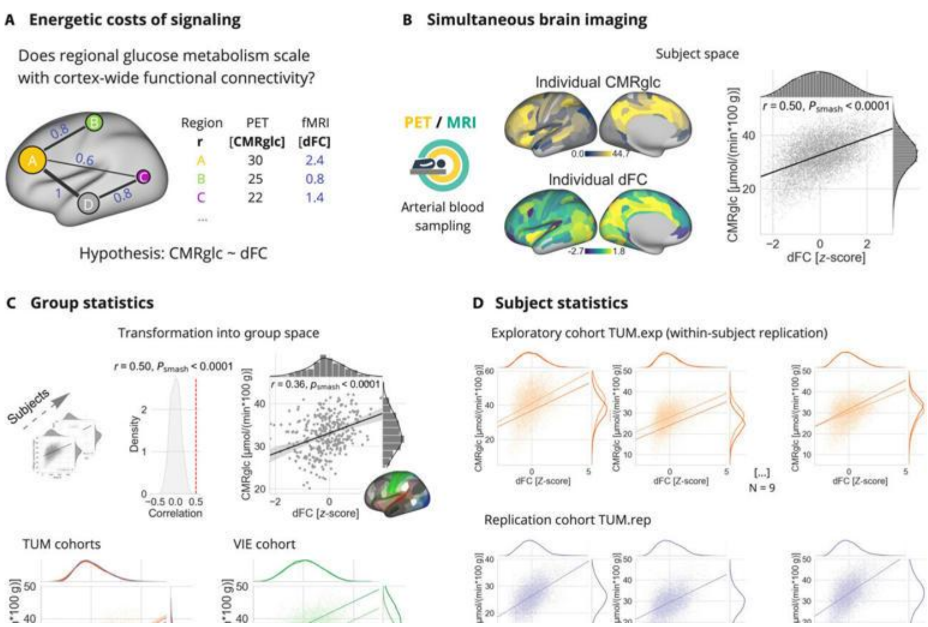
One other signal the brain uses to store information is the intensity of the emotion associated with it. You're more likely to form a memory when a situation is particularly exciting, shocking, painful, or upsetting than when it elicits only a mild emotional response. The intensity and energy associated with the event influences the brain's calculation that this information is likely to be useful later.

One reason that intensity matters is that intense emotions are often associated with important events or surprising events. You are elated because you have completed a significant goal. Or you are shocked because a highly surprising (and potentially dangerous) thing has happened. Or you are angry because someone or something has blocked you from doing something important.

Storing that information may be valuable in many ways. For example, when you experience a great shock, you may not have much of a chance to analyze what happened (and potentially what went wrong) in the moment. By storing a memory of the event, it gives you information you can think about later to help prevent you from experiencing a similar unpleasant surprise in the future.

There is much more to be said about what gets the brain to remember things. Whole books could be written on the topic (and indeed, several have). But the principles here give you at least some way of thinking about how to make it more likely you'll remember things later (even if you don't recall reading this particular article in the future).

Human intelligence: How cognitive circuitry, rather than brain size, drove its evolution



Glucose metabolism scales linearly with the degree of functional connectivity in individual brains. Credit: Science Advances (2023). DOI: 10.1126/sciadv.adi7632© Provided by Phys.org

It's one of the great paradoxes of evolution. Humans have demonstrated that having large brains are key to our evolutionary success, and yet such brains are extremely rare in other animals. Most get by on tiny brains, and don't seem to miss the extra brain cells (neurons).

Why? The answer that most biologists have settled on is that large brains are costly in terms of the energy they require to run. And, given the way natural selection works, the benefits simply don't exceed the costs.

But is it just a matter of size? Does the way our brains are laid out also affect their costs? A new study, published in *Science Advances*, has produced some intriguing answers.

All our organs have running costs, but some are cheap and others expensive. Bones, for example, are relatively cheap. Although they make up around 15% of your weight, they only use 5% of your metabolism. Brains are at the other end of the spectrum, and at about 2% of typical human body weight, running them uses around 20% of our metabolism. And this without doing any conscious thinking—it even happens when we're asleep.

For most animals, the benefits of serious thinking are simply not worth it. But for some reason—the greatest puzzle in human evolution, perhaps—humans found ways to overcome the costs of having a larger brain and reap the benefits.

All this is fairly well known, but there is a more tantalizing question. Certainly humans have to bear the greater costs of our brains because they are so large, but are there different costs because of the special nature of our cognition? Does thinking, speaking, being self-conscious or doing sums cost more than typical day-to-day animal activities?

It's not an easy question to answer, but the team behind the new study, led by Valentin Riedl of the Technical University of Munich, Germany, have risen to the challenge.

The authors had a number of known points to start with. The basic design and structure of neurons is much the same across the brain—and across species. The neuronal density is also the same for humans and other primates, so these are unlikely to be the driver of intelligence. If they were, some animals with large brains such as orcas and elephants would likely be smarter than humans.

They also knew that across human evolution, the neocortex—the largest part of the outermost layer of the brain, known as cerebral cortex—has expanded at a greater rate than other parts. This region, which involves the prefrontal cortex, is responsible for tasks involving attention, thought, planning, perception and episodic memory—all needed for higher cognitive function.

These two observations led them to investigate whether there are different costs of signaling across different regions of the brain.

The team scanned the brains of 30 people using a technique that could simultaneously measure glucose metabolism (a measure of energy consumption) and the level of signaling across the cortex. They could then look at the correlation between these two elements and see whether different parts of the brain used different levels of energy—and if so how.

Surprising findings

Neurobiologists will surely ponder and explore the fine details of the results, but from an evolutionary point of view, they are thought-provoking. What they found is that the difference in energy consumption between different areas of the brain is big. Not all bits of the brain are equal, energetically speaking.

Not only that, but the parts of the human brain that have expanded most had higher costs than expected. The neocortex in fact demanded around 67% more energy than sensorimotor networks per gram of tissue.

This means that during the course of human evolution, not only did the metabolic costs of our brains go up as they became larger, but they did so at an accelerating rate as the neocortex expanded faster than the rest of the brain.

Why should that be the case? A neuron is a neuron, after all. The neocortex relates directly to higher cognitive function.

The signals sent across this area are mediated through brain chemicals such as serotonin, dopamine and noradrenaline (neuromodulators), which create circuits in the brain to help maintain a general level of excitement (in a neurological sense of the word meaning being awake, not having fun). These circuits, which regulate some brain areas more than others, control and modify the ability of neurons across the brain to communicate with each other.

In other words, they keep the brain active for memory storage and thinking—a generally higher level of cognitive activity. Not surprisingly, perhaps, the higher level of activity involved in our advanced cognition comes at a higher energetic cost.

Ultimately then, it seems the human brain evolved to such advanced levels of cognition not just because we have large brains, nor even just because certain areas of our brain grew disproportionately big, but because—at a cost—the connectivity improved.

Many animals with large brains, such as elephants and orcas, are highly intelligent. But it seems it is possible to have a large brain without developing the "right" circuitry for human-level cognition.

The results help us understand why larger brains are so rare. A larger brain can enable more complex cognition to evolve. It is not just a matter of scaling up brains and energy at the same rate though, but taking on additional costs.

This doesn't really answer the ultimate question—how did humans manage to break through the brain-energy ceiling? As so often in evolution, the answer must lie in ecology, the ultimate source of energy. To grow and maintain a large brain—whatever social, cultural, technological or other things it is used for—requires a dependable and high quality diet.

To learn more, we need to explore the last million years, the period when our ancestors' brains really expanded, to investigate this interface between energy expenditure and cognition.

More information: Gabriel Castrillon et al, An energy costly architecture of neuromodulators for human brain evolution and cognition, *Science Advances* (2023). DOI: 10.1126/sciadv.adi7632

Conditions That Change the Brain

PTSD

When you go through something traumatic, your brain triggers a "flight-or-fight" response. Most people recover on their own, but some get posttraumatic stress disorder. PTSD causes your amygdala — the part of the brain that controls emotions — to be overactive. And it lowers activity in your prefrontal cortex, a decision-making area. It can also shrink your hippocampus, which forms memories.

Depression

Depression doesn't affect just your mood. The disorder can change your brain. Experts say it lessens activity in some brain areas, including your prefrontal lobes, which are involved with things like reasoning, personality, and judgment. One study found that people who were depressed for more than a decade had about 30% more brain inflammation. This may lead to brain cell loss, which would make memory problems and dementia more likely.

Stroke

Strokes happen when blood flow to part of your brain stops. They cause permanent brain damage and can lead to death and disability. Your symptoms will depend on where your stroke happens. If it's on the left side of the brain, you may have weakness or numbness on the right side of your body, and speaking may be tough as well. If your stroke is on the right side of the brain, you may have weakness or numbness on your left side.

Alcohol Use Disorder

It's no secret that alcohol affects the brain. It can cause blurry vision, slurred speech, and memory loss. That's because alcohol kills brain cells. Over time, drinking too much can damage your brain. Research shows that it can shrink certain parts of your brain, too. Some experts say that people with alcoholism have a smaller hippocampus — the area important for learning and memory — than those who don't drink often.

Schizophrenia

People with schizophrenia have different brains than those without this mental disorder. Scans show they lose gray and white matter, the fatty material that makes up the brain. White matter sits deep in the brain, where information travels. Gray matter surrounds it and, among other things, helps the brain process information. In people who have schizophrenia, gray matter tends to leave first, with white matter going away over time.

Alzheimer's Disease

Your brain has cells called neurons. They "talk" to each other through chemical and electrical signals, and send messages to the rest of your body. Alzheimer's disease disrupts this communication. It's thought that the breakdown comes from a buildup of two proteins, amyloid and tau. Both create tangles that might disrupt messages.

Migraines

People who get migraines have faulty wiring in their brain. Certain nerves overreact to triggers, such as stress or bright light. This sets off a wave of activity, which causes chemicals to narrow blood vessels in the brain. That brings the headache and other symptoms. Over time, chronic migraines might cause you to lose some gray and white matter.

Brain Aneurysm

A brain aneurysm is weak spot in a blood vessel. It usually balloons or bulges out and fills with blood. Many look like a berry hanging on a thin stem. They often form on arteries at the base of the brain. Some aneurysms leak or rupture. That causes bleeding in the brain or the area between your brain and its lining. These are hemorrhagic strokes. They can start as headaches but can lead to nausea, seizures, and death.

Concussions

Any number of mishaps, such as a car crash, contact sports, or bump to the head, can cause a concussion. During impact, the brain slides and bumps into the inside of the skull. This can bruise the brain and tear nerve tissue. Concussions also shake up the balance of chemicals in the brain, harming nerve cell function and triggering inflammation. While the brain usually heals on its own, getting multiple concussions may lead to long-lasting damage.

Bipolar Disorder

Scientists are still looking at the brain changes responsible for the intense mood changes of bipolar disorder. They think they're the result of imbalances of neurotransmitters. These chemicals send messages between brain cells. They play a role in things like mood, sleep, and memory. For example, too much of a neurotransmitter called noradrenaline can cause mania, while too little sets the stage for depression.

Multiple Sclerosis

When you have MS, your immune system attacks the nerves in your brain and spinal cord. Your body sends white blood cells to harm the myelin, the layer of insulation around nerves. This causes nerve damage, and disrupts the flow of information to and from the brain. Over time, scar tissue forms on the nerves and creates lesions. These changes lead to things like numbness, tremors, and vision problems.

ADHD

Experts think ADHD symptoms, like inattention and hyperactivity, come from brain differences. Research shows there's less gray and white matter in people with ADHD. Certain areas also take longer to take shape. What's more, networks of nerve cells work differently. These networks send signals in the brain, and they play a role in attention and focus.

Meditation

This mind-body practice eases stress and boosts mental health. Now, research reveals that it may actually change your brain. One study found that meditating for 2 months increased gray matter in parts of the brain that control emotions and learning. Meditation also strengthens the connection between brain cells. It may also ease inflammation in the brain and protect against Alzheimer's disease.

Exercise

Getting moving is good for the body and brain. Exercise pumps blood to the brain, which delivers oxygen and nutrients. It also stimulates the release of proteins that keep brain cells healthy and help grow new ones. Research shows that exercise may grow the areas of your brain that control thinking and memory.

How brain evolution is linked to the use of tools

A researcher demonstrates which tasks the participants were asked to perform during the experiment—here in the planning phase: on the left, making precise cuts in leather; on the right, cracking nuts using stone tools. Credit: University of Tübingen

Researchers led by Dr. Alexandros Karakostis from the Institute for Archaeological Science and the Senckenberg Center for Human Evolution and Palaeoenvironment at the University of Tübingen suggest that changes in the brain could have enabled early humans to use tools with precision, thus setting in motion the biocultural evolution that led to today's humans.

The team's experimental study took a new approach. The researchers recorded the brain waves of test subjects while they were using stone tools of the kind used by early humans. The results of the study have been published in the journal *Scientific Reports*.

"Technological innovations were crucial for human evolution," says Karakostis. "We are interested in what cognitive developments were necessary for the use of relatively simple stone tools—and where humans and other primates differ in their abilities."

In the experiment, the researchers investigated two different types of tool use. First, the participants were asked to crack nuts using a stone as a hammer, and second, they were asked to cut patterns in leather using chipped stones.

"We replicated stone tools to mirror those discovered in the early archaeological record," explains Simona Affinito, Ph.D. student in Karakostis' research group and first author of the study. While nut-cracking with stones has also been observed in various animals such as monkeys and apes, the habitual use of chipped stones for cutting is only seen in humans.

Differing cognitive requirements

The activity patterns in the test subjects' brains were recorded in parallel in an electroencephalogram (EEG) as the subjects sought to complete the tasks. "Our study provides empirical evidence to support distinct patterns of brain activity during different behaviors and stages of early hominin tool use," explains Affinito.

"The involvement of the frontoparietal regions, particularly during the aiming stage, highlights the importance of these brain areas in planning motor actions."

Although both tasks required cognitive effort, the use of cutting tools involved significantly more extensive brain activity than nut-cracking, Karakostis reports. "These differences implicitly highlight the cognitive performance required for precise tool-using tasks. They likely enabled early humans to appropriate and shape their environment in a way that was not possible before," he says.

The new study has created the basis for further research into the cognitive prerequisites for human technological progress.

More information: Simona Affinito et al, Exploring the cognitive underpinnings of early hominin stone tool use through an experimental EEG approach, *Scientific Reports* (2024). DOI: 10.1038/s41598-024-77452-0

Provided by University of Tübingen

What does neurotypical, neurodivergent, and neurodiverse mean?

The word "neurotypical" describes someone who thinks and processes information in ways that are typical within their culture. They tend to learn skills and reach developmental milestones around the same time as their peers.

In contrast, the term "neurodivergent" describes someone who processes information in a different way. Autistic people and those with attention deficit hyperactivity disorder (ADHD) and similar conditions sometimes identify as neurodivergent.

These words can be a way of moving discussions away from focusing on a disease or mental health disorder, implying instead that people simply have a different way of understanding and interacting with the world.

However, some argue that the term “neurodiversity” is better still. This word refers to various ways that individuals think and behave. Rather than frame one way as typical and the other as atypical, “neurodiversity” embraces a continuum of possibilities.

In this article, we will look at what it means to be neurotypical and neurodivergent and explore some traits that share associations with these words. We will also look at neurodiversity and its benefits.

What does neurotypical mean?

The term neurotypical describes someone who thinks and processes information in an expected way for their culture and setting.

Some characteristics that people associate with neurotypical development include:

- reaching developmental milestones at a similar time to other children, such as learning to speak
- having social or organizational skills that are similar to someone’s peers
- being able to tolerate some sensory discomfort, such as loud noises, without much difficulty
- being able to adapt to changes in routines
- being able to focus in class or at work for prolonged periods
- having varied interests or hobbies typical for the person’s age

A neurotypical person does not necessarily have all of these traits or have them in all situations to identify as neurotypical.

For example, some people without autism may feel overwhelmed by certain sensory experiences, such as being in a crowd. Some children also have delays in learning speech or other skills that are not a result of any diagnosis.

The meaning "neurotypical" is also subjective, to an extent. What people consider typical can vary according to context.

For example, a 2018 studyTrusted Source comparing data from the United States, India, and Japan looked at the characteristics doctors use to distinguish autistic from allistic — or nonautistic — people. Researchers found that while many traits were consistent across groups, others depended on the culture.

What does neurodivergent mean?

The term "neurodivergent" describes people who process information and behave in a way that differs from the actual or perceived norms of a particular culture. It is a way to discuss diagnoses, such as autism, in a way that does not frame it as a problem or an illness.

According to the United Kingdom charity ADHD Aware, 30–40% of the population are neurodivergent. As with the term "neurotypical," though, the term has no fixed meaning.

Neurodivergence comes in many forms. People with the following may consider themselves neurodivergent:

- **ADHD:** People with ADHD oftenTrusted Source have high levels of energy, which may cause hyperactivity and difficulty sitting still at school or work. Therefore, staying focused or organized can also be difficult. However, these traits can also mean people with ADHD are spontaneous and dynamic.

- **Learning disabilities:** Learning disabilities affect how someone learns or takes in information. For example, dyslexia affects a person's ability to read, while dysgraphia affects handwriting and fine motor skills. People with these diagnoses are not unintelligent or incapable of learning — in fact, they often have average or above-average intelligence. However, they can benefit from learning in different ways.
- **Autism:** Autism affects how someone processes sensory information and how they think and communicate. For example, an autistic individual may be very sensitive to certain sounds and noises or have trouble reading social cues. Others may have very specific, in-depth interests. The effects vary greatly from person to person.
- **Tourette's syndrome:** People with Tourette's syndrome have a neurological condition that causes them to make involuntary movements or sounds, known as tics.
- **Synesthesia:** Individuals with synesthesia experience the senses in different ways. They may see colors or shapes when they hear music or taste certain flavors when they hear words. They may only experience this in their "mind's eye," or externally in the world around them.

Some consider rare forms of giftedness to be part of neurodivergence too. For example, people with hyperthymesia have a highly accurate memory of their own life experiences.

Does neurodivergence include mental health?

The above diagnoses are not mental health conditions — they are neurodevelopmental in origin. They come with long term traits that do not change over time.

However, some people consider mental health conditions to be part of neurodivergence because they can also change how someone thinks and behaves. People with these conditions can also face some of the same challenges, such as feeling misunderstood or experiencing stigma.

However, mental health conditions have some characteristics that make them distinct:

- **Quality of life:** Being neurodivergent does not necessarily reduce quality of life. In the right circumstances, people who identify as such can lead fulfilling lives. However, a supportive environment does not prevent mental health conditions from affecting quality of life.
- **Identity:** For many, neurodiversity is part of their identity. Some may also feel this way about their mental health condition. In some situations, this viewpoint could cause harm. For example, seeing anorexia as a lifestyle or identity can mean people do not seek treatment, which could be fatal.
- **Treatment:** Finally, many mental health conditions are treatable and can improve significantly with support and therapy. The same is not true for autism, learning disabilities, and other types of neurodivergence. Though there is no cure for these diagnoses, appropriate support can help people learn the skills they find challenging.

ADHD Aware states that eventually, some long term conditions that people consider psychological, such as schizophrenia or antisocial personality disorder, may ultimately become part of the concept of neurodivergence or neurodiversity.

The more scientists discover how these conditions work, the more the language will evolve.

What is neurodiversity?

Neurodiversity refers to the wide spectrum of ways that people think. It frames differences in cognition as variations, all of which are equally normal and valuable.

The concept became popular in the 1990s, when sociologist Judy Singer proposed that autism arises from the brain working differently from nonautistic individuals. She also highlighted that this is not a fault but a difference. Neurodiversity has since become a movement, changing how people see autism and other diagnoses.

Neurodiversity advocates may still use the terms “neurotypical” and “neurodivergent” to identify where they are on the neurodiversity spectrum or talk about others. However, everyone is included in neurodiversity, regardless of how their brain functions.

Which terms are better?

There are mixed opinions on whether the terms “neurotypical” and “neurodivergent” are helpful.

Some feel that “neurotypical” is an accurate reflection of how many people understand the world and social interactions in a similar or typical way.

The word can also reflect the privileges from which neurotypical people can benefit. Because their peers consider them “typical,” people who fall into this category often have an easier time in school, the workplace, and relationships.

However, others say that calling one group “typical” reinforces the idea that while some people think typically, others think atypically. A 2021 paper argues that this is both scientifically inaccurate and harmful.

The authors say that diversity in how people think is a natural product of evolution and that it is natural for human brains and bodies to vary. To consider one type of cognition “typical” ignores this fact.

How a person identifies and describes themselves is ultimately a personal choice. Generally, it is a good idea to use the terms an individual prefers.

What are the benefits of neurodiversity?

Supporters for neurodiversity believe that variations in thinking are beneficial to society, adding different perspectives and ideas. Teaching children about neurodiversity may:

- reduce fear about the way their brain works or how they differ from others
- encourage them to see differences as normal and natural
- teach them about being aware of harmless behaviors, such as stimming
- help cultivate healthy self-esteem
- empower children to advocate for their needs, for example, if they are have reading difficulties in class
- feel confident about their unique abilities

On a personal level, the benefits for adults are very similar. Learning about neurodiversity can change how people see themselves or those around them.

On a broader scale, acceptance of neurodiversity may:

- help parents and caregivers understand and care for their children
- help teachers understand how best to educate children with a range of needs
- encourage employers to hire neurodiverse people, reducing unemployment
- increase positive representations of neurodiversity in the media
- decrease stigma, bullying, and discrimination

Summary

The word “neurotypical” refers to people who have brains that function in a similar way to most of their peers. Individuals who are neurotypical develop skills, such as social or organizational skills, at around the same rate as others their age. They can also tolerate change, disruption in routines, and distractions without too much difficulty.

In contrast, people who consider themselves neurodivergent have brains that function differently. They may have a diagnosis such as ASD, ADHD, dyslexia, or Tourette’s syndrome. Neurodivergence comes in many forms, and they affect people with these diagnoses differently.

'Noisy' autistic brains seem better at certain tasks. Here's why neuroaffirmative research matters

Autism is a neurodevelopmental difference associated with specific experiences and characteristics.

For decades, autism research has focused on behavioral, cognitive, social and communication difficulties. These studies highlighted how autistic people face issues with everyday tasks that allistic (meaning non-autistic) people do not. Some difficulties may include recognizing emotions or social cues.

But some research, including our own study, has explored specific advantages in autism. Studies have shown that in some cognitive tasks, autistic people perform better than allistic people. Autistic people may have greater success in identifying a simple shape embedded within a more complex design, arranging blocks of different shapes and colors, or spotting an object within a cluttered visual environment (similar to Where's Wally?). Such enhanced performance has been recorded in babies as young as nine months who show emerging signs of autism.

How and why do autistic individuals do so well on these tasks? The answer may be surprising: more "neural noise."

What is neural noise?

Generally, when you think of noise, you probably think of auditory noise, the ups and downs in the amplitude of sound frequencies we hear.

A similar thing happens in the brain with random fluctuations in neural activity. This is called neural noise.

This noise is always present, and comes on top of any brain activity caused by things we see, hear, smell and touch. This means that in the brain, an identical stimulus that is presented multiple times won't cause exactly the same activity. Sometimes the brain is more active, sometimes less. In fact, even the response to a single stimulus or event will fluctuate continuously.

Neural noise in autism

There are many sources of neural noise in the brain. These include how the neurons become excited and calm again, changes in attention and arousal levels, and biochemical processes at the cellular level, among others. An allistic brain has mechanisms to manage and use this noise. For instance, cells in the hippocampus (the brain's memory system) can make use of neural noise to enhance memory encoding and recall.

Evidence for high neural noise in autism can be seen in electroencephalography (EEG) recordings, where increased levels of neural fluctuations were observed in autistic children. This means their neural activity is less predictable, showing a wider range of activity (higher ups and downs) in response to the same stimulus.

In simple terms, if we imagine the EEG responses like a sound wave, we would expect to see small ups and downs (amplitude) in allistic brains each time they encounter a stimulus. But autistic brains seem to show bigger ups and downs, demonstrating greater amplitude of neural noise.

Many studies have linked this noisy autistic brain with cognitive, social and behavioral difficulties.

But could noise be a bonus?

The diagnosis of autism has a long clinical history. A shift from the medical to a more social model has also seen advocacy for it to be reframed as a difference, rather than a disorder or deficit. This change has also entered autism research. Neuroaffirming research can examine the uniqueness and strengths of neurodivergence.

Psychology and perception researcher David Simmons and colleagues at the University of Glasgow were the first to suggest that while high neural noise is generally a disadvantage in autism, it can sometimes provide benefits due to a phenomenon called stochastic resonance. This is where optimal amounts of noise can enhance performance. In line with this theory, high neural noise in the autistic brain might enhance performance for some cognitive tasks.

Our 2023 research explores this idea. We recruited participants from the general population and investigated their performance on letter-detection tasks. At the same time, we measured their level of autistic traits.

We performed two letter-detection experiments (one in a lab and one online) where participants had to identify a letter when displayed among background visual static of various intensities.

By using the static, we added additional visual noise to the neural noise already present in our participants' brains. We hypothesized the visual noise would push participants with low internal brain noise (or low autistic traits) to perform better (as suggested by previous research on stochastic resonance). The more interesting prediction was that noise would not help individuals who already had a lot of brain noise (that is, those with high autistic traits), because their own neural noise already ensured optimal performance.

Indeed, one of our experiments showed people with high neural noise (high autistic traits) did not benefit from additional noise. Moreover, they showed superior performance (greater accuracy) relative to people with low neural noise when the added visual static was low. This suggests their own neural noise already caused a natural stochastic resonance effect, resulting in better performance.

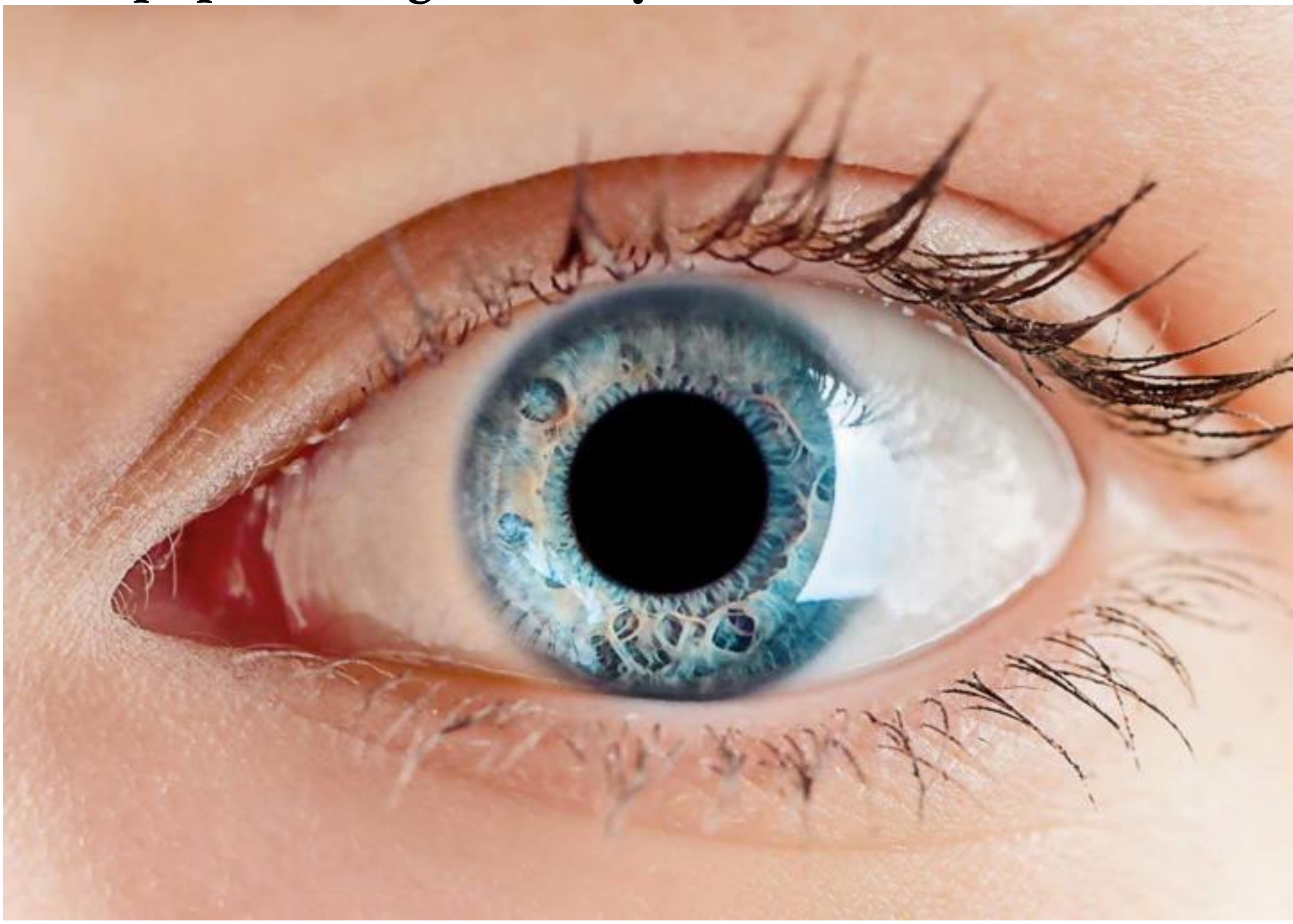
It is important to note we did not include clinically diagnosed autistic participants, but overall, we showed the theory of enhanced performance due to stochastic resonance in autism has merits.

Why this is important?

Autistic people face ignorance, prejudice and discrimination that can harm well-being. Poor mental and physical health, reduced social connections and increased "camouflaging" of autistic traits are some of the negative impacts that autistic people face.

So, research underlining and investigating the strengths inherent in autism can help reduce stigma, allow autistic people to be themselves and acknowledge autistic people do not require "fixing." The autistic brain is different. It comes with limitations, but it also has its strengths.

Your pupils change size as you breathe



Pupil size can help diagnose conditions such as concussion Irina Shilnikova/Getty Images© Provided by New Scientist

The size of our pupils fluctuates as we breathe. They are at their smallest as we start to breathe in, increase steadily to reach their largest size when we are in the middle of breathing out, then shrink rapidly as we finish exhaling.

"I haven't tried to see it with my naked eye," says Martin Schaefer at the Karolinska Institute in Stockholm, Sweden. "I think it would be difficult to see."

The fact that breathing can affect pupil size has been known for decades, but all the scientific papers that Schaefer found mentioning this effect say the size is largest during inhalation and smallest when exhaling.

Fascia: The long-overlooked tissue that shapes your health

When he looked into these claims, Schaefer found that they were based on studies of anaesthetised cats and don't even hold true for conscious cats, so he decided to do a study in people.

His team used a specialised camera to measure the pupil size of 100 volunteers while monitoring their breathing with a sensor-equipped mask. When pupil size was analysed over many breath cycles, a clear pattern emerged: the size was smallest at the start of inhaling and largest in the middle of exhaling.

This relationship held true whether the volunteers breathed through their mouth or nose, and whether they just looked at one spot on a screen for 5 minutes or carried out a simple on-screen task.

However, the pattern often wasn't clear over a single breath cycle. This is because pupil size is influenced by a lot of factors, which can mask the breathing effect, says Schaefer.

Our vision is sharpest when our pupils are smaller, but bigger pupils are more sensitive to faint stimuli, especially in our peripheral vision, he says. His team is now asking more volunteers to carry out various visual tasks to see if the changes in pupil size due to breathing have a measurable impact on people's performance.

Schaefer is also investigating whether we can intentionally change the size of our pupils by controlling our breathing. If so, the findings could help people who rely heavily on vision, such as in sports like shooting.

Pupil size is also used to help diagnose some conditions, such as concussion, he says. "Therefore, just understanding what influences pupil size better is very helpful for scientists."

Schaefer thinks the breathing effect occurs because the part of the brain stem that controls inhaling and exhaling has links to the pupils. Whether or not this is an accidental result of brain evolution isn't clear, he says. "Is this just an artefact, or is there a purpose behind it? We don't really know yet."

Reference:

bioRxiv DOI: 10.1101/2024.06.27.599713

Scientists are close to understanding what sets our brain apart from other species

3,000 types of cells

Your brain has billions of cells, but they come in relatively few types: a little over 3,000 cells combine to build our brains and make us who we are.

Different wiring=different functions

However, the most critical difference between our brains and those of other primates is not in the cells but in the wiring between them.

The decade of the brain

That discovery has been part of many that researchers have done in the past decade, filled with breakthroughs on our path to understanding the human brain.

A detailed brain atlas

For that, an international team of scientists is creating the most detailed atlas of our brain, mapping the locations and functions of 170 billion cells.

The BRAIN project

The international research project is part of the BRAIN (Brain Research Through Advancing Innovative Neurotechnologies) Initiative, with laboratories across many disciplines.

Humans, primates and rats

BRAIN researchers identify, characterize, and map the brain cells of humans, other primates, and rats, hoping to make critical discoveries about our brains as a base for new studies on diseases and brain function.

Mice, the basic plan

The researchers have fully mapped mice brains and found we have different cells. Humans, for example, have specialized cells for visual processing that mice don't.

What sets us apart

However, the difference in other primates is much more subtle. Trygve Bakken, an assistant investigator at the Allen Institute, told PBS that the differences are in language processing.

Different connections and proportions

Cell proportion sets us apart from other mammals in the area of the brain that processes language. We have similar cells but in different proportions.

Gene expression

However, in the case of other large primates, and particularly our closest relatives, Chimpanzees, the difference is not in the composition of the brain or the cells but simply in the genetic expression of those cells.

Long way to go

Those findings can lay a foundation for more research, but the BRAIN initiative still has a long way to go.

Intricate maps

Mapping the brain is a difficult task. Ed Lein, a neuroscientist at the Allen Institute for Brain Science, told The Washington Post that each part is as complex as a complete organ. From Stanford University, Henry Greely compared it to sending a spaceship to another planet.

Comprehensive data

The BRAIN initiative serves as a great source of data, but it is still not aimed at understanding the complexity of brain functions like memory or consciousness. Other studies are trying to tackle that.

A dictionary

For example, BRAIN developed a dictionary linking certain genetic changes to specific brain cell types, which could give researchers crucial data to study the mechanics behind brain diseases.

New techniques and tools

The BRAIN studies also helped develop techniques that will add to the advanced tools researchers already have to understand our brain, like MRI and EEG scans.

So do we understand the brain yet?

However, there is still much to learn about how our brain works. Brain expert and UC Berkeley Professor Doris Tsao told Cosmos Magazine: "What we know about the brain, including my work, is trivial."

Want Better Mental Focus? Neuroscience Just Explained How to Train Your Brain to Achieve 'Flow State'

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 intensely" than their less 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.'"

Human brains are getting bigger, here's why that's good news

The human brain is getting bigger which could be good news in the battle to beat dementia.

The surface area of a modern brain is around 15 percent larger than in the 1930s, researchers have found, with the volume increasing by 6.6 percent.

A team from the University of California Davis analyzed 75 years' worth of brain changes between generations.

Dr. Charles DeCarli, director of the UC Davis Alzheimer's Disease Research Center said: "Larger brain structures like those observed in our study may reflect improved brain development and improved brain health.

"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."

The study, published in the journal JAMA Neurology used brain magnetic resonance imaging (MRIs) from participants in the Framingham Heart Study (FHS) from 1999 and 2019.

This was launched in 1948 in Massachusetts, to analyze patterns of cardiovascular and other diseases.

The original cohort consisted of 5,209 men and women ages 30 to 62.

The research has continued and now includes second and third generations of participants.

These participants were born during the 1930s through to the 1970s.

Dr DeCarli, added: "The decade someone is born appears to impact brain size and potentially long-term brain health.

"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."

The brain study consisted of 3,226 participants, with 53 percent female and an average age of about 57 at the time of the MRI.

Researchers found gradual but consistent increases in several brain structures.

For participants born in the 1930s, the average brain volume was 1,234 milliliters, compared to 1,321 milliliters for those born in the 1970s, or about 6.6 percent greater volume.

But the cortical surface area, a measure of the brain's surface, showed an even greater increase over time.

Those born in the 1970s had an average surface area of 2,104 square centimeters compared to 2,056 square centimeters for participants born in the 1930s, almost a 15 percent increase in area.

The researchers found brain structures such as white matter also increased in size when comparing the two groups.

A previous study found a 20 percent reduction in the incidence of dementia per decade since the 1970s.

Fascinating neuroscience research reveals a key mechanism underlying human cognition

(Photo credit: DALL·E)© PsyPost

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."

New state of mind: Rethinking how researchers understand brain activity

Credit: Pixabay/CC0 Public Domain© Provided by Medical Xpress

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.

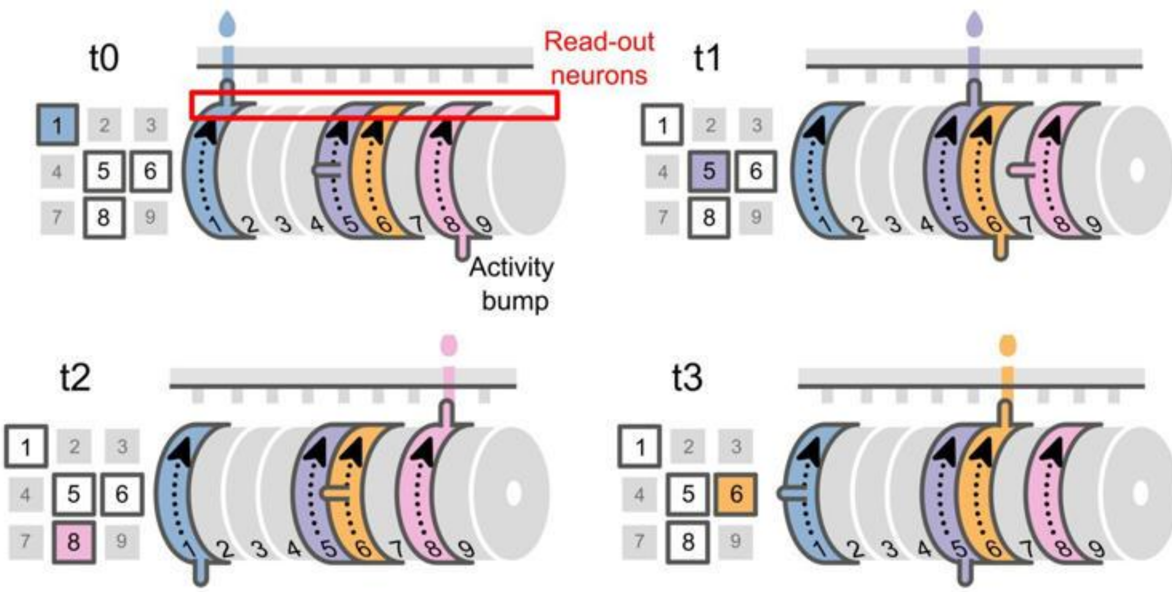
What's it like as someone who has been in this field for a while to have a student come in with a new idea like this?

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

Provided by Yale University

Neuroscientists reveal how cells in the brain form a coordinate system for behavioral sequences



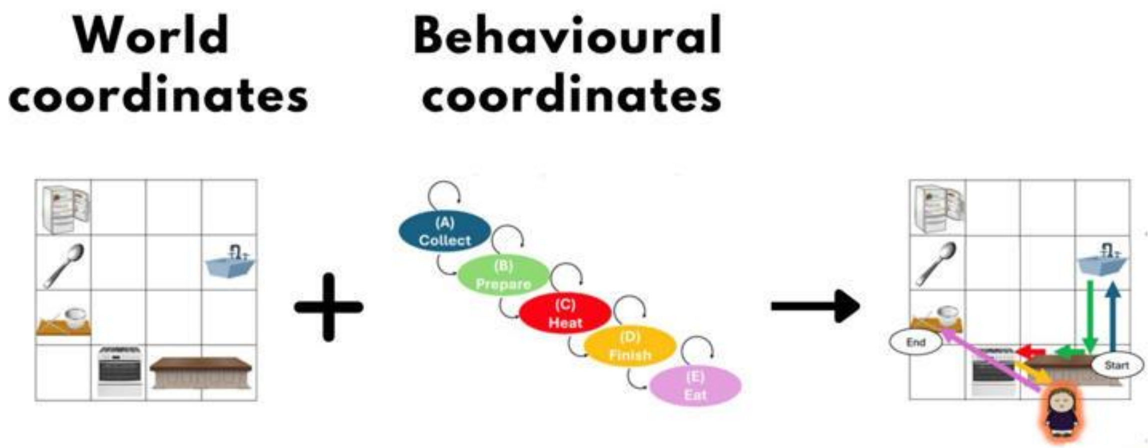
The brain acts like a music box in the way that it can be configured to play behavioral actions. Credit: Dr. Gil Costa.

Neuroscientists have discovered brain cells that form multiple coordinate systems to tell us "where we are" in a sequence of behaviors. These cells can play out different sequences of actions, just like a music box can be configured to play different sequences of tones.

The findings help us understand the algorithms used by the brain to flexibly generate complex behaviors, such as planning and reasoning, and might be useful in understanding how such processes go wrong in psychiatric conditions such as schizophrenia.

The research, published in *Nature,* outlines how scientists at the Sainsbury Wellcome Center at UCL and University of Oxford studied mice learning different behavioral sequences but with the same structure. This allowed the team to uncover how mice generalize structures to new tasks, a hallmark of intelligent behavior.

"Every day we solve new problems by generalizing from our knowledge. Take cooking, for example. When faced with a new recipe, you are able to use your background knowledge of similar recipes to infer what steps are needed, even if you have never made the meal before," said Dr. Mohamady El Gaby, first author on the study and postdoctoral neuroscientist in the Behrens lab at the Sainsbury Wellcome Center at UCL and Nuffield Department of Clinical Neurosciences, University of Oxford.



To solve the problem of how to cook a meal, the brain must combine world coordinates with behavioural coordinates. Credit: Dr. Matthew Nour.

"We wanted to understand at a detailed cellular level how the brain achieves this and also to infer from this brain activity the algorithms being used to solve this problem."

The researchers gave mice a series of four goal locations. While the details of the sequences were different, the general structure was the same. Mice moved between the goal locations (A B C and D) that repeated in a loop.

"After experiencing enough sequences, the mice did something remarkable—they guessed a part of the sequence they had never experienced before. When reaching D in a new location for the first time, they knew to go straight back to A. This action couldn't have been remembered, since it was never experienced in the first place! Instead, it's evidence that mice know the general structure of the task and can track their 'position' in behavioral coordinates," explains Dr. El Gaby.

To understand how the mice learned the general structure of the task, the researchers used silicon probes that allowed them to record the activity of multiple individual cells from an area of the brain called the medial frontal cortex. They found that the cells collectively mapped the animal's "goal progress." For example, one cell could fire when the animal is 70% of the way to its goal, regardless of where the goal is or how far it takes to reach it.

"We found that the cells tracked the animal's behavioral position relative to concrete actions. If we think of the cooking analogy, the cells cared about progress towards subgoals such as chopping the vegetables. A subset of the cells were also tuned to map the progress towards the overall goal, such as finishing preparing the meal. The 'goal progress' cells therefore effectively act as flexible building blocks that come together to build a behavioral coordinate system," said Dr. El Gaby.

In effect, the team found that the cells form multiple coordinate systems, each telling the animal where it is relative to a specific action. In a similar way to a music box that can be configured to play any sequence of tones, the brain can instead "play" behavioral actions.

The team are now working to understand how these activity patterns are built into the brain's connections, both when learning new behaviors, and how they start to emerge in the developing brain. In addition, early work from the group and their collaborators suggests similar brain activity is present in equivalent circuits in healthy humans.

This has encouraged the team to work with psychiatrists to understand how these processes are affected in conditions like schizophrenia, which is known to involve the same brain circuits. This could help explain why people with schizophrenia overestimate their progress to goals leading to delusions.

More information: Mohamady El-Gaby, A cellular basis for mapping behavioural structure, *Nature* (2024). DOI: 10.1038/s41586-024-08145-x. www.nature.com/articles/s41586-024-08145-x

Provided by Sainsbury Wellcome Centre

Meanings of Words Have Been Detected in The Flicker of Individual Brain Cells

Illustration of two neurons with a signal of light passing between them© Provided by ScienceAlert

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.

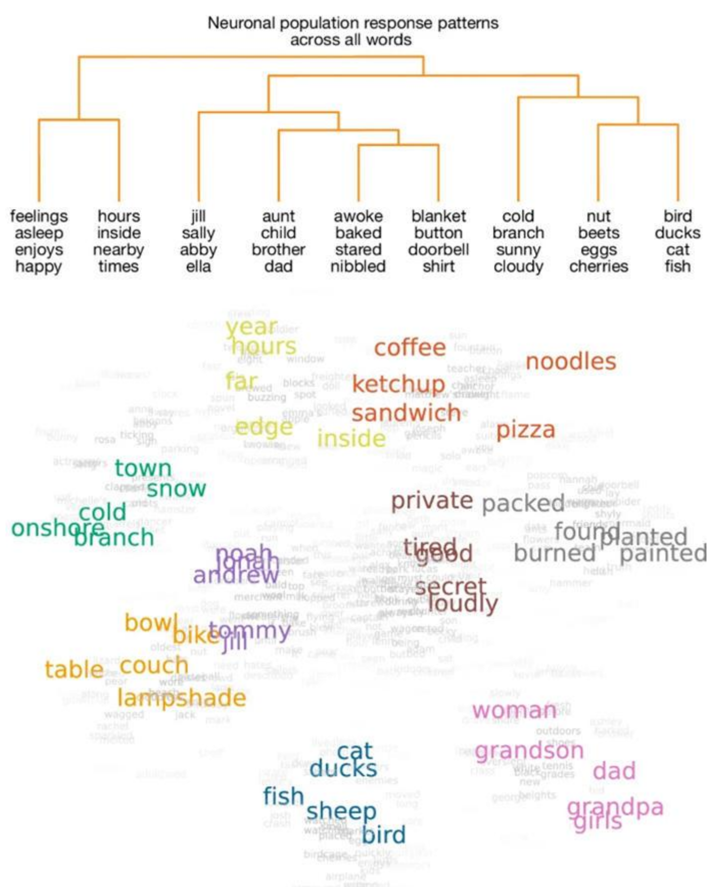
"Humans possess an exceptional ability to extract nuanced meaning through language – when we listen to speech, we can comprehend the meanings of up to tens of thousands of words and do so seamlessly across remarkably diverse concepts and themes," says Harvard University neuroscientist Ziv Williams.

"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 an

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*.

3D brain mapping opens a window to the aging brain

Zhongliang Zu, PhD, left, and John Gore, PhD, are leading an effort to map brain networks in three dimensions. Credit: Erin O. Smith© Provided by Medical Xpress

By mapping brain activity in three dimensions, researchers at Vanderbilt University Medical Center have achieved a more detailed picture of how the brain changes with age.

Their findings, described in the Jan. 26 issue of the journal *Science Advances*, may help advance the understanding, early diagnosis and treatment of Alzheimer's disease, bipolar disorder and other disruptions of normal brain function.

Half of the human brain is made up of gray matter, nerve cells that process sensation, control voluntary movement, and enable speech, learning and cognition. The other half is white matter, the axons that connect areas of gray matter to each other and project to the rest of the body.

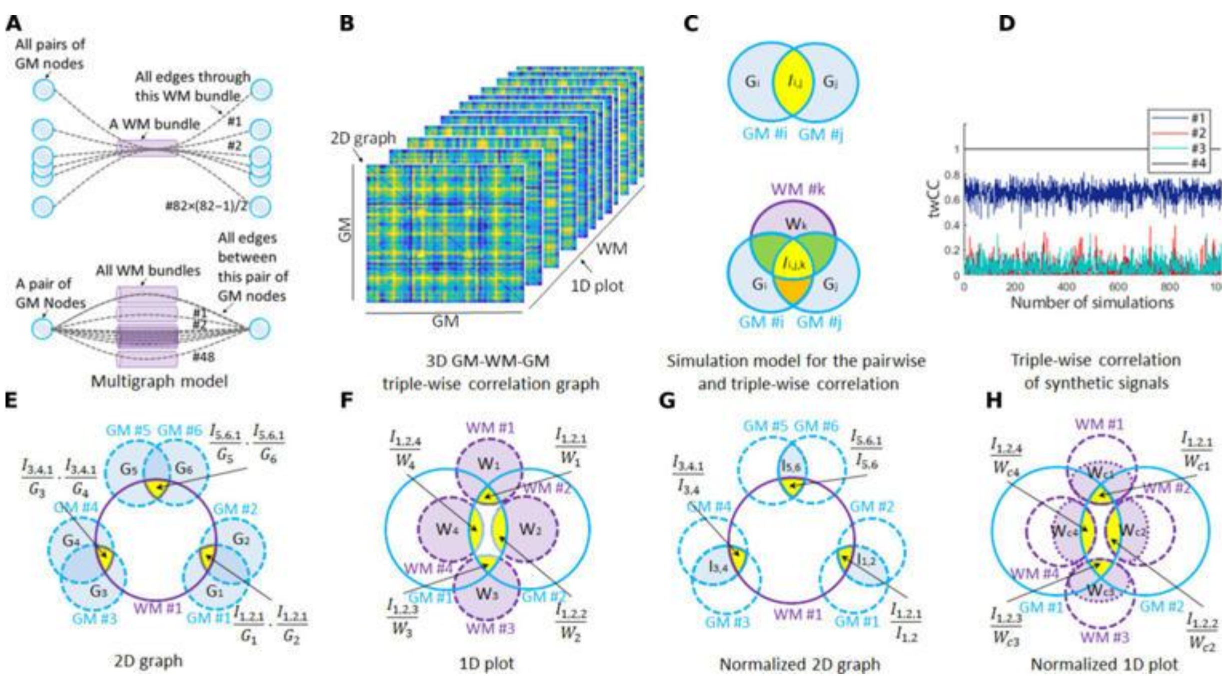


Illustration of the triple-wise correlation network model. Credit: Science Advances (2024). DOI: 10.1126/sciadv.adi0616© Provided by Medical Xpress

Within the field of functional magnetic resonance imaging (fMRI) of the brain, white matter historically has been understudied, in part because it is easier to detect functional signals from gray matter.

Recently VUMC scientists found they can reliably separate and detect white matter signals, opening the door to better understanding of the other, previously neglected half of the brain.

Now they've taken the research to the next level. Through a complicated series of mathematical formulas, the paper's first author, Zhongliang Zu, Ph.D., has proposed a method for simultaneously mapping how areas of gray matter "talk to each other" through connections of white matter.

"It's a major extension of using brain imaging to study brain networks, but bringing in, for the first time, white matter," said John Gore, Ph.D., director of the Vanderbilt University Institute for Imaging Science and the paper's corresponding author.

A major technique for studying brain activity, fMRI measures changes in blood oxygenation-level dependent (BOLD) signals that, in gray matter, reflect a rise in blood flow (and oxygen) in response to increased neuronal activity.

While BOLD signals in white matter are less well understood, it is becoming clear that white matter is not passive tissue that merely connects areas of gray matter.

White matter "plays a pivotal role in human learning processes," the VUMC scientists state in their paper. Changes in the microstructure of white matter "alter the fidelity of neural signal transmissions and consequently brain function."

Prior research has determined the functional connectivity between two areas of gray matter by correlating their BOLD signals.

As described in the current paper, Zu, research associate professor of Radiology and Radiological Sciences and of Biomedical Engineering, conceived a "triple-wise correlational framework" that incorporates signals from white matter into the study of functional connectivity pathways.

Using fMRI images of the brains of 490 individuals from publicly accessible databases and by applying multivariant statistical methods, Zu, Gore and their colleagues were able to determine that white matter fibers form multiple and complex gray matter connections.

"A white matter fiber may carry signals from multiple potential inputs to different gray matter areas," Gore explained. "At the same time, any pair of gray matter areas might communicate through many different (white matter) pathways."

Zu's mathematical equations have worked out how much each pair of gray matter contributes to signal transmission through a single white matter fiber and, at the same time, how much each pair uses different fibers. "That's really a major step," Gore said.

Incorporating white matter signals provides, as the paper's title suggests, the "missing third dimension" to understanding functional connectivity between different brain regions.

By studying the brain scans of different age groups, the researchers discovered that overall connectivity in parts of the brain declined with age, while brain activation increased in the frontal cortex, which is involved in higher cognitive function.

This shift is possibly to compensate for the decline in other areas, they noted.

The researchers are now investigating what the functional consequences might be of vascular changes in white matter that have been associated with brain disorders such as Alzheimer's disease.

In the future, measuring changes in functional connectivity between brain regions could serve as a biomarker—a way to monitor the progression of diseases that affect white matter and response to treatment, Gore said.

More information: Zhongliang Zu et al, The missing third dimension—Functional correlations of BOLD signals incorporating white matter, *Science Advances* (2024). DOI: 10.1126/sciadv.adi0616

Provided by Vanderbilt University

Old people can produce as many new brain cells as teenagers

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.

1mm-thick speakers could reshape smart glasses, smartwatches, and earbuds

XMEMS, the company that created the first speaker based on a microchip manufacturing processes, is getting set to release its next wave of tiny speakers. Known as Sycamore, the newest model is just 1.13 mm thick, and weighs only 150 milligrams, yet it can reproduce full-range sound over short distances — like the gap between your ears and the limbs of your smart glasses — according to xMEMS.

Sycamore is the latest step in the evolution of micro speakers.XMEMS' first version could be used in wireless earbuds to reproduce high frequencies, but needed the help of a dynamic driver for bass. Its second product could do full-range sound, but was still limited to earbuds that seal the ear canal with a silicone tip. Sycamore is the company's first micro speaker that reproduce full-range sound without the need of a closed, sealed environment.


xMEMS

The company is extolling the many audio benefits of the Sycamore driver as compared to traditional speaker technologies: "With its first-order low-frequency roll-off, it can match mid-bass performance of legacy drivers while offering as much as 11 [decibels] headroom in sub-bass extension. Sycamore also pushes the performance envelope on high-frequency sound — by as much as 15dB above 5KHz over legacy drivers."

In other words, the Sycamore is expected to produce better lows and highs. It's also remarkably robust, with an IP58 rating that makes it impervious to water and highly resistant to dust.

xMEMS

However, it's really Sycamore's size that's expected to spur designers of electronics into creating better products. It's one-seventh the size of a conventional dynamic driver package, according to xMEMS, and one-third the thickness. That difference alone could yield smart glasses with thinner, more fashionable limbs, thinner and more durable smartwatches, and open-ear earbuds that are smaller and sound better.

XMEMS also predicts that there will be other uses for Sycamore. With its high-frequency performance, it could act as a tweeter in automotive headrests, Bluetooth speakers, and laptops. The company thinks it could also yield clearer calls and greater privacy when used as an earpiece speaker in smartphones.

All of this is still speculative. XMEMS won't be releasing Sycamore manufacturing samples to prospective electronics companies until the first quarter of 2025, and says that mass production won't begin until October 2025. Still, with these timelines, we could see the first Sycamore-enabled products announced in time for CES 2026.

The Latest Tech News, Delivered to Your Inbox

This article may contain affiliate links that Microsoft and/or the publisher may receive a commission from if you buy a product or service through those links.

Give your brain a workout using music and this EEG wearable

Alphabeats, a company that uses music to give your brain a workout, has returned after its initial launch earlier this year with a new partnership that makes the technology more accessible to more people. It has teamed up with Muse to integrate its unusual training method into the brand's high-tech headbands with built-in electroencephalogram (EEG) sensors.

Muse wearers will be able to use the Alphabeats app to play music, which is tuned to their brainwaves and then adapted to make a HIIT-style workout for the mind, training it to improve focus, promote relaxation, or to meditate. Your brainwaves are tracked by the Muse headband and visualized in the Alphabeats app, while the headband comes with a new feature called the Brain Recharge Score, allowing you to understand how your brain is reacting to stress and demanding tasks over time.

Jorrit DeVries, Alphabeats CEO, said this about the partnership:

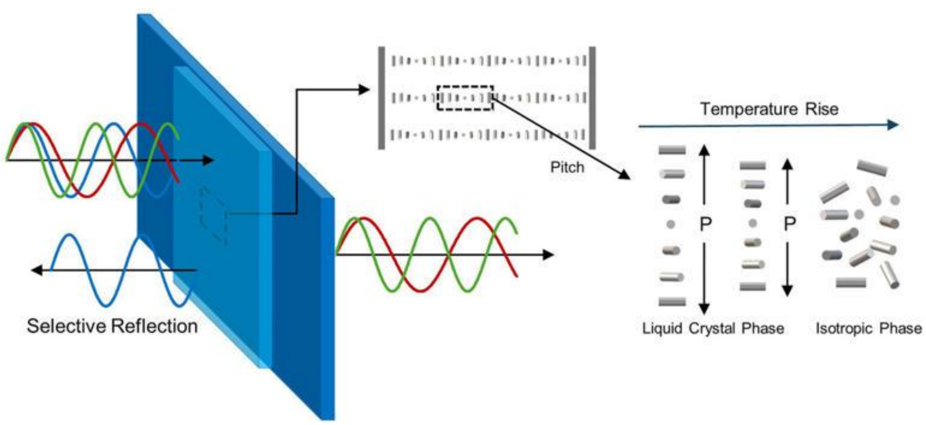
"Music is the key to making mental training both effective and engaging, a finding we've proven with professional athletes over the past decade. Muse has built strong credibility through their affordable, high-quality hardware solutions. By integrating our one-of-a kind music-driven training with their platform, we can offer professional-grade mental training at a more accessible price point to more people."

Both Alphabeats and Muse claim their products can help athletes improve performance, and research published by industry journal Applied Psychophysiology and Biofeedback showed soccer players using Alphabeats technology "increased their ability to reach an optimal mental state by 34%," while the University of Toronto showed golfers attaining better putting scores after seven minutes using a Muse headband.

When we last talked about Alphabeats it had partnered with Brainbits. The package of EEG hardware and software cost $689, and was primarily targeted at athletes and professional sports people. Muse is an established name in the world of EEG-based brain health hardware, and its products are much cheaper. During an early promotional period the Muse 2 with one-year's access to the Alphabeats app costs $199, which will increase to $399 after the promotion ends.

Alphabeats is a subscription-based service, and it has now confirmed it will cost $149 per year to access the platform, but if you already own a Muse 2 or a Muse S headband there's a special introductory price of $79 for a year available. Alphabeats is one of the more unusual health and fitness products we've seen, and if you're interested in finding out if exercising your brain with music actually works, it'll be worth picking up the $199 deal for a Muse 2 and Alphabeats.

Prototype lenses can block epileptic-seizure causing wavelengths



Schematic diagram of a thermal-controlled CLC lens that can reflect certain wavelengths of light. Credit: Cell Reports Physical Science (2024). DOI: 10.1016/j.xcrp.2024.102158

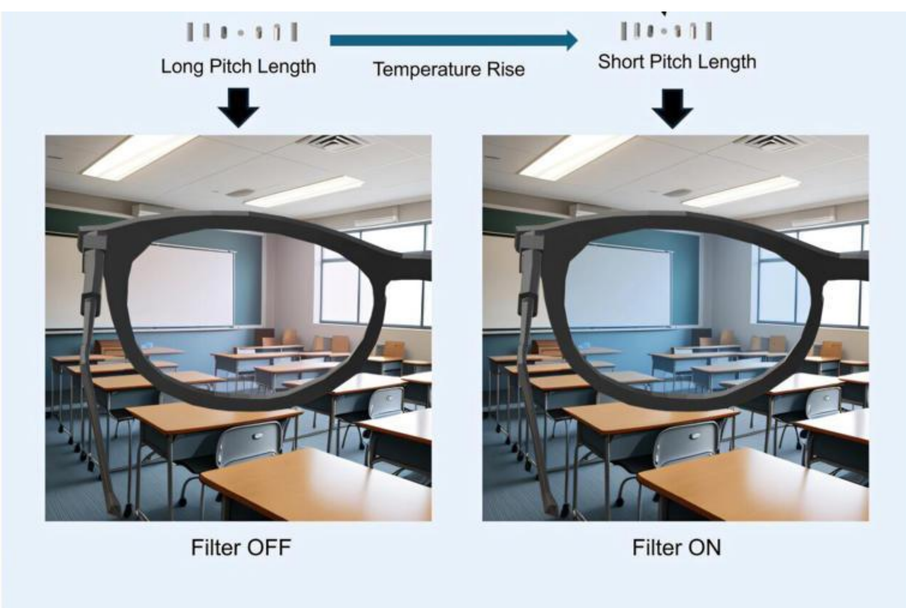
People with photosensitive epilepsy could benefit from a prototype pair of glasses with lenses that block out wavelengths that are known to cause seizures in some people.

In a study published in *Cell Reports Physical Science*, researchers from the University of Glasgow and University of Birmingham have developed a prototype of a liquid crystal lens that they believe could help photosensitive epilepsy sufferers.

The lenses are controlled by very small changes in temperature that can be built into the lens, and when activated can block more than 98% of light in the 660–720nm wavelength range, known to affect the greatest number of people suffering from photosensitive epilepsy.

Zubair Ahmed, Professor of Neuroscience at the University of Birmingham and co-author of the study said, "This is a hugely exciting project that felt like a science fiction project when we first started the work four years ago. This paper demonstrates the potential for the use of liquid crystal lenses that can be modulated to cut out specific wavelengths of light."

"The prototype shows how a discrete circuit installed in the frame of a pair of glasses can power these lenses and be used in situations where a certain wavelength of light is likely to trigger a seizure, such as while watching TV or playing computer games. The circuit heats up the lenses to a comfortable temperature for wearers that will also cut out more than 98% of light with a wavelength that can cause seizures."



Graphical abstract. Credit: Cell Reports Physical Science (2024). DOI: 10.1016/j.xcrp.2024.102158

Rami Ghannam, Professor of Electronics at the University of Glasgow and lead author of the study said, "The project shows how collaboration between different disciplines such as engineering, neuroscience and mathematics can bring about potential discoveries that could transform the lives of patients affected by various diseases."

"We are now developing this protype further to improve its performance before we take this into human studies."

The authors note that the current prototype was functional in rooms up to 26°C temperatures, and further tweaks to the technology would be needed to cater for uses in hotter environments. The team also note that the time taken for the prototype to heat and cool could be improved.

More information: Yuanjie Xia et al, Thermal-controlled cholesteric liquid crystal wavelength filter lens for photosensitive epilepsy treatment, *Cell Reports Physical Science* (2024). DOI: 10.1016/j.xcrp.2024.102158

Provided by University of Glasgow

Researchers develop miRNA-tunable living interface for neurovascular remodeling

Design of the LIFES. LIFES imparts topographical, piezoelectric, and photo-pyroelectric signals for cell modulation,

enabling fine-tuned exosome secretion, which facilitates neurovascular remodeling. Credit: SIAT

A research team led by Dr. Du Xuemin from the Shenzhen Institutes of Advanced Technology (SIAT) of the Chinese Academy of Sciences has reported a living interface with unique functionalities of durable secretion of bioactive exosomes with tunable contents and miRNA cargoes, effectively promoting neurovascular remodeling.

The study was published in *Matter* on Nov. 21.

Neurovascular remodeling is crucial for restoring normal functions of regenerated tissues or engineered organs, which requires multi-target and phase-specific paracrine regulation. However, existing strategies still cannot mimic such dynamic and complicated paracrine regulation effects in the native physiological processes, hindering synergistic neurovascular remodeling.

Exosomes, as key entities in the native paracrine process, show great promise for neurovascular remodeling yet still face challenges. Direct exosome administration is limited by its short lifetime (24–48 hours). In addition, exosome delivery systems struggle with preserving bioactivity and maintaining adaptable miRNA cargoes throughout the entire release period, limiting their effectiveness at different stages of neurovascular remodeling.

The proposed living interface in this study for fine-tuned exosome secretion (LIFES) consists of two core elements, a poly(vinylidene fluoride-co-trifluoro ethylene)-based intelligent material layer with rationally designed topographical structures and superior electric properties for cell modulation, and a living cell layer with rat bone marrow-derived mesenchymal stem cells (MSCs) for efficient biogenesis of exosomes.

Through the synergistic interactions between the two core elements, LIFES can secrete bioactive exosomes in sustained (~192 hours) and phase-specific manners, with tunable contents (~8-fold increases) and programmable miRNA cargoes (initially pro-angiogenic and later pro-neurogenic).

"The phase-specific exosome secretion of LIFES meets physiological requirements, which aligns with the native multi-target and multi-stage paracrine regulation effects observed in physiological neurovascular remodeling processes," said Dr. Du.

By mimicking the natural paracrine regulation effects within the native physiological processes of neurovascular remodeling, LIFES effectively promotes the reconstituting of vascular neural networks, even in challenging diabetic wound models.

Researchers develop miRNA-tunable living interface for neurovascular remodeling

Design of the LIFES. LIFES imparts topographical, piezoelectric, and photo-pyroelectric signals for cell modulation,

enabling fine-tuned exosome secretion, which facilitates neurovascular remodeling. Credit: SIAT

A research team led by Dr. Du Xuemin from the Shenzhen Institutes of Advanced Technology (SIAT) of the Chinese Academy of Sciences has reported a living interface with unique functionalities of durable secretion of bioactive exosomes with tunable contents and miRNA cargoes, effectively promoting neurovascular remodeling.

The study was published in *Matter* on Nov. 21.

Neurovascular remodeling is crucial for restoring normal functions of regenerated tissues or engineered organs, which requires multi-target and phase-specific paracrine regulation. However, existing strategies still cannot mimic such dynamic and complicated paracrine regulation effects in the native physiological processes, hindering synergistic neurovascular remodeling.

Exosomes, as key entities in the native paracrine process, show great promise for neurovascular remodeling yet still face challenges. Direct exosome administration is limited by its short lifetime (24–48 hours). In addition, exosome delivery systems struggle with preserving bioactivity and maintaining adaptable miRNA cargoes throughout the entire release period, limiting their effectiveness at different stages of neurovascular remodeling.

The proposed living interface in this study for fine-tuned exosome secretion (LIFES) consists of two core elements, a poly(vinylidene fluoride-co-trifluoro ethylene)-based intelligent material layer with rationally designed topographical structures and superior electric properties for cell modulation, and a living cell layer with rat bone marrow-derived mesenchymal stem cells (MSCs) for efficient biogenesis of exosomes.

Through the synergistic interactions between the two core elements, LIFES can secrete bioactive exosomes in sustained (~192 hours) and phase-specific manners, with tunable contents (~8-fold increases) and programmable miRNA cargoes (initially pro-angiogenic and later pro-neurogenic).

"The phase-specific exosome secretion of LIFES meets physiological requirements, which aligns with the native multi-target and multi-stage paracrine regulation effects observed in physiological neurovascular remodeling processes," said Dr. Du.

By mimicking the natural paracrine regulation effects within the native physiological processes of neurovascular remodeling, LIFES effectively promotes the reconstituting of vascular neural networks, even in challenging diabetic wound models.

Daily habits like sleep and exercise can shape brain connectivity for weeks

A new study published in PLOS Biology provides fascinating insights into how our daily experiences and behaviors, such as sleep patterns, physical activity, and even our mood, leave lasting imprints on our brain's connectivity. Conducted by researchers at Aalto University and the University of Oulu, the study used brain scans and data from wearable devices to track the brain activity and physiological states of a single participant over 133 days.

The new findings challenge the common perception that brain connectivity is influenced only by immediate events, revealing instead that behaviors from up to 15 days prior can continue to shape the brain's functional connections. This suggests that short-term fluctuations in our environment and physiological states play a much more sustained role in brain dynamics than previously thought.

The researchers were motivated by the idea that human brains do not function in isolation. Ana Triana, the lead researcher, explained that our behavior and mental states are constantly influenced by a wide range of factors, including our environment, physical health, and emotional experiences. However, much of what is currently known about brain connectivity comes from short-term studies or cross-sectional research, which capture only snapshots of brain activity at a single point in time. These designs, while informative, might miss the more extended and complex effects that daily life has on brain function.

Triana and her team wanted to investigate whether behaviors, moods, and physiological changes like heart rate variability or sleep patterns continue to influence brain activity over a more extended period. This approach could provide a more accurate understanding of how our mental and physical states are intertwined with brain connectivity over days and weeks, rather than just minutes or hours.

"We wanted to go beyond isolated events," Triana said. "Our behavior and mental states are constantly shaped by our environment and experiences. Yet, we know little about the response of brain functional connectivity to environmental, physiological, and behavioral changes on different timescales, from days to months."

The study took a unique approach by focusing on just one participant—Ana Triana herself. Over a period of 133 days, Triana's daily activities, sleep patterns, heart rate, and mood were continuously monitored using wearable devices, including a smartwatch and a ring designed to track physiological data.

"The use of wearable technology was crucial," Triana explained. "Brain scans are useful tools, but a snapshot of someone lying still for half an hour can only show so much. Our brains do not work in isolation."

Additionally, she completed surveys about her mood and experiences twice a day. This data was complemented by functional magnetic resonance imaging (fMRI) scans conducted twice a week, which measured her brain's connectivity in different contexts, including rest, attention tasks, and memory tasks.

Each fMRI scan provided a detailed picture of how different regions of Triana's brain communicated with each other while she performed tasks or simply rested. By combining the fMRI data with the physiological and behavioral data collected through wearables and surveys, the researchers could explore how changes in behavior and physical health impacted brain connectivity over time.

One of the key metrics the study focused on was heart rate variability (HRV), which is an indicator of how adaptable the heart is to changes in the body's physiological state, such as during stress or relaxation. By analyzing this in conjunction with brain scans, the researchers could explore the relationship between physiological health and brain connectivity in real-world conditions.

The study found strong evidence that the brain's connectivity evolves in response to external and internal factors over time, and not just in the immediate aftermath of a given event. For instance, a restless night of sleep or an intense workout from several days ago could still be shaping the way different parts of the brain communicate with each other up to 15 days later.

The research identified two distinct patterns in brain connectivity: a short-term wave lasting about seven days, which likely reflects rapid adaptations to more immediate factors like sleep quality, and a longer-term wave of changes that extends to around 15 days, showing more gradual, lasting effects.

One of the study's more surprising findings was the link between HRV and brain connectivity, particularly during periods of rest. Higher heart rate variability, which typically indicates a better capacity to handle stress, was associated with more efficient communication between brain regions, especially in areas related to attention and memory. This suggests that the body's ability to manage stress may have a lasting effect on the brain's functional architecture, even when the brain is not actively focused on a specific task.

Physical activity also played an important role in shaping brain connectivity. Higher levels of daily movement were associated with stronger connections between brain regions, which could imply that regular exercise supports the brain's ability to stay flexible and adapt to new challenges. On the flip side, days with less physical activity were linked to weaker brain connectivity, particularly in areas responsible for attention and cognitive flexibility.

Interestingly, the researchers found that these effects were not limited to the immediate aftermath of a specific behavior. For example, shifts in mood, sleep quality, or physical activity left lasting imprints on brain connectivity that persisted for days or even weeks. The brain appears to retain a "memory" of these behaviors, allowing them to influence brain function well beyond the moment they occurred.

Limitations and Directions for Future Research

While the study's findings are exciting, they come with important limitations. One major limitation is the fact that the study was conducted with only a single participant, which makes it difficult to generalize the findings to the broader population. While this single-case design allowed the researchers to gather incredibly detailed data over a long period, it's unclear whether the same patterns would be observed in other people. The specific lifestyle, physiological makeup, and emotional responses of the participant might differ significantly from those of others, leading to different results.

Future studies could benefit from a larger sample size to see if these brain-behavior relationships hold across different individuals with varied lifestyles and health conditions. Additionally, while the study focused on the effects of behavior and physiological states on brain connectivity, it did not explore whether changes in brain connectivity could, in turn, influence future behavior or physiological responses. Investigating this bidirectional relationship could offer a more comprehensive understanding of how the brain and body interact over time.

Another direction for future research could be the use of more complex statistical models to explore how different factors, such as sleep, mood, and physical activity, interact with each other to influence brain connectivity. The current study looked at these variables in isolation, but in reality, they are likely to have complex, interdependent effects on the brain's functional networks.

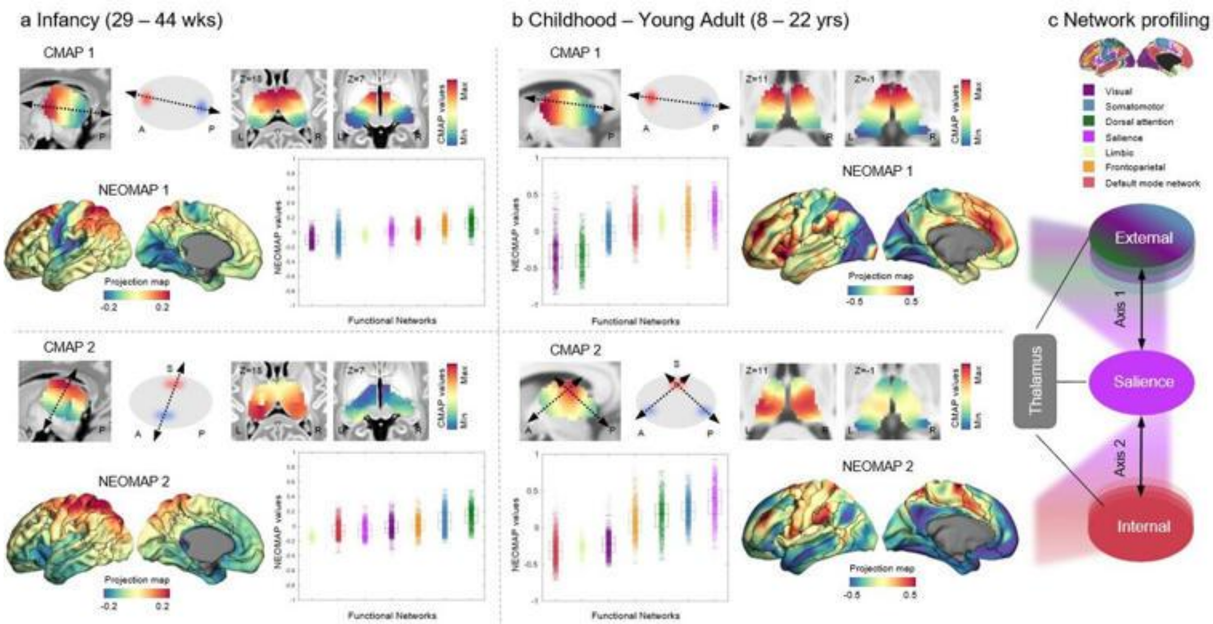
Finally, the researchers pointed out that while they tracked changes over a 15-day period, it is unknown whether behaviors from even further back in time might have an impact on brain connectivity. Future studies could extend the observation period to explore whether certain behaviors or physiological states have even longer-lasting effects on brain function.

"We must bring data from daily life into the lab to see the full picture of how our habits shape the brain, but surveys can be tiring and inaccurate," said study co-author, neuroscientist and physician Nick Hayward. "Combining concurrent physiology with repeated brain scans in one person is crucial. Our approach gives context to neuroscience and delivers very fine detail to our understanding of the brain."

"Linking brain activity with physiological and environmental data could revolutionize personalized healthcare, opening doors for earlier interventions and better outcomes," added Triana.

The study, "Longitudinal single-subject neuroimaging study reveals effects of daily environmental, physiological, and lifestyle factors on functional brain connectivity," was authored by Ana María Triana, Juha Salmi, Nicholas Mark Edward Alexander Hayward, Jari Saramäki, and Enrico Glerean.

Thalamocortical connectivity crucial for functional brain networks, study finds

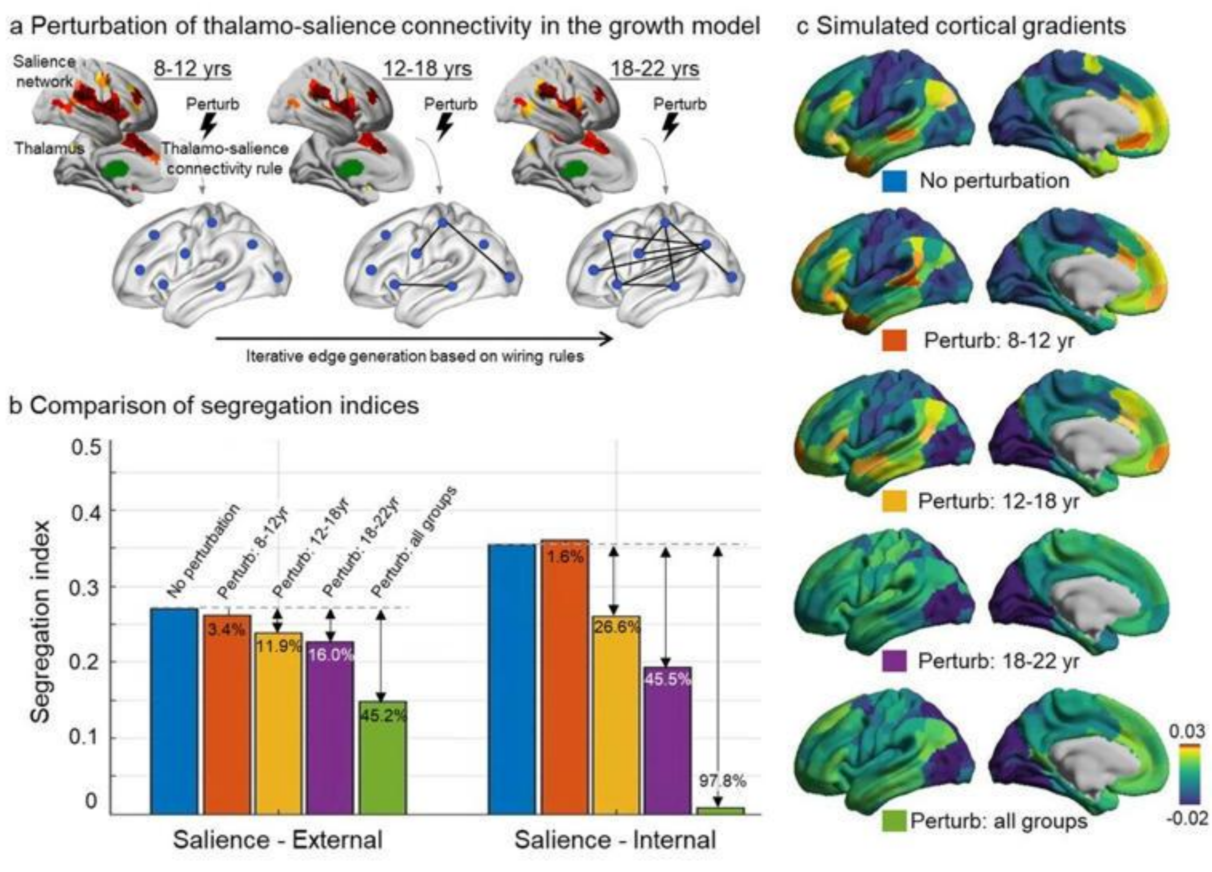


Thalamic connectopic maps (CMAP) and neocortical projection maps (NEOMAP) demonstrate the developmental changes in brain connectivity. Panel (a) shows CMAP 1 & 2 and NEOMAP 1 & 2 for infants (29–44 weeks), illustrating early differentiation of sensorimotor networks. Panel (b) displays these maps for children and young adults (8–22 years), highlighting the establishment of connections with the salience network and the differentiation between externally and internally oriented systems. Network profiles, sorted based on the Yeo-Krienan 7 Network Atlas, are depicted in box plots indicating the median and interquartile range (IQR). Panel (c) presents a schematic of the external-to-internal axis division derived from the NEOMAPs of childhood and young adulthood, showing the crucial role of the salience network. Credit: Nature Neuroscience (2024). DOI: 10.1038/s41593-024-01679-3© Provided by Medical Xpress

Our brains seamlessly process streams of visual information from the world around us while simultaneously understanding the causal structure of events. These essential cognitive functions, known as external sensory processing and internal world modeling, are critical for navigating complex environments.

Our brain achieves this through large-scale functional systems responsible for these processes. Recently, an international collaboration of scientists led by the Institute for Basic Science (IBS) has explored the role of thalamocortical connectivity during the development of brain networks. The study is published in *Nature Neuroscience*.

One longstanding question in neuroscience is how the brain's large-scale functional networks form during development. This study investigated the changes in connectivity between the thalamus and cerebral cortex from infancy to adulthood and how these changes influence the formation of the brain's functional networks. For the first time, researchers have revealed that thalamocortical connectivity is crucial for the emergence and specialization of the brain's functional networks, particularly those processing external and internal information.



Perturbation of developmentally informed growth models. (a) A schematic illustrates the growth model based on thalamo-salience connectivity rules that change over the developmental age span. Four perturbation models were tested: perturbation applied to the 8–12 years age group, 12–16 years age group, 16–22 years age group, and all age groups, compared to a non-perturbation model. (b) The segregation indices (salience-external and salience-internal) were calculated for each growth model, with percentages indicating the difference compared to the no-perturbation model. (c) Cortical gradients extracted from the simulated affinity matrix of each growth model demonstrate the impact of these perturbations on brain connectivity development. Credit: Nature Neuroscience (2024). DOI: 10.1038/s41593-024-01679-3© Provided by Medical Xpress

Traditionally seen as a relay station for sensory information, the thalamus also influences higher cognitive functions. Sensory connections between the thalamus and cortex become established quickly at an early age, while higher-order cognitive connections develop later at maturity. However, the exact mechanisms and timeline of these developments have remained unclear.

This study began to address these challenges by employing advanced neuroimaging techniques, transcriptomic analyses, and computational models on cross-sectional and longitudinal datasets, to map the development of thalamocortical connectivity across different age groups.

This study revealed that during infancy, thalamocortical connectivity reflects early sensorimotor network differentiation and gene expression patterns related to brain development. However, as children grow, this connectivity shifts its role to establish connections with the salience network, that serves as an anchor for differentiating external (sensorimotor, visual, dorsal attention networks) and internal (default mode network) functional cortical systems.

Computational simulations confirmed thalamic connectivity's role in developing key features of the mature brain, such as functional segregation and the sensory-association axis.

"Our study for the first time provides a detailed map of how thalamocortical connectivity contributes to the large-scale functional organization in the human brain from infancy through young adulthood," said lead author Park Shinwon.

"By integrating advanced neuroimaging techniques, gene expression analysis, and computational modeling, we were able to systematically track and analyze the changes in brain connectivity across different developmental stages. This comprehensive approach has allowed us to uncover the pivotal role of the thalamus in the emergence and specialization of functional brain networks."

Unlike earlier studies that focused on regional properties of individual thalamic nuclei, this research provides a comprehensive view of the global integration of the thalamus into cortical networks. These findings offer potential implications for understanding and studying clinical conditions that show compromised internal and external processing, such as autism, schizophrenia, and other neurodevelopmental conditions.

The corresponding author, Hong Seok Jun, a principal investigator at the IBS Center for Neuroscience Imaging Research said, "Understanding how thalamocortical connectivity evolves and influences brain function provides a crucial foundation for identifying the mechanisms underlying neurodevelopmental conditions.

"This research opens up new possibilities for early diagnosis and targeted interventions, which could significantly improve outcomes for individuals with neurodevelopmental conditions."

In the future, the researchers plan to investigate how thalamocortical connectivity changes in children with autism and how these changes correlate with clinical symptoms and cognitive functions. They also plan to expand their research focus to include other subcortical structures such as the striatum and cerebellum.

This broader approach in systems neuroscience will help us gain a more comprehensive understanding of how various brain regions interact and develop.

More information: Shinwon Park et al, A shifting role of thalamocortical connectivity in the emergence of cortical functional organization, *Nature Neuroscience* (2024). DOI: 10.1038/s41593-024-01679-3

Provided by Institute for Basic Science

Apple deepens dive into smart glasses with internal study

Apple has launched a comprehensive study of smart glasses, marking an initial move towards exploring the booming wearable technology category. The project, which insiders have dubbed “Atlas,” started last week and aims to assess the user experience and functionality of current smart glasses on the market.

The initiative involves Apple's Product Systems Quality team, which works within Apple's hardware engineering division.

Apple studies the current market for smart glasses

As part of this project, Apple is gathering feedback from its employees on smart glasses available today. This feedback is essential as Apple studies current user expectations, preferences, and challenges associated with existing models. According to sources close to the study, Apple also plans additional focus groups in the coming weeks. These sessions aim to gather in-depth insights, providing data that could influence the design of any future Apple smart glasses, Bloomberg reported.

An internal email from the hardware team emphasized Apple's commitment to creating products that consumers will value and enjoy. "Testing and developing products that all can come to love is very important to what we do at Apple," stated the email, which invited employees at Apple's Cupertino headquarters to join Apple's study on smart glasses research.

Meta., a notable player in the smart glasses sector, has already entered the space with a partnership with Ray-Ban, launching glasses that allow users to take photos, make calls, and interact with an AI assistant. In contrast, Apple's study highlights a more cautious approach, suggesting Apple is looking to craft a unique path that could set its product apart from Meta's offerings. The ongoing Apple study smart glasses project indicates the company may prioritize seamless integration with its ecosystem, similar to the appeal of its AirPods.

Apple's vision for lightweight wearables

Apple's recent research initiatives, including an app for tracking blood sugar levels, indicate its interest in health and lifestyle enhancements through wearable technology. However, while the Vision Pro headset introduced earlier this year offers advanced features, its bulk and high price limit mainstream appeal. Apple's current study may be a step toward developing lighter, more accessible smart glasses that could serve as an everyday device.

For now, it remains uncertain when or if Apple will officially introduce a smart glasses product. However, with fellow technology-driven competitors like Meta and Snap moving forward, Apple's continued exploration could pave the way for a competitive entry into the smart glasses market in the years to come.

'Mind diet' could stave off thinking and memory problems, study finds

Following the Mind diet – which is rich in leafy vegetables, berries, nuts and beans – could stave off thinking and memory problems, according to new research.

Experts said it was "critical" to find changes that people could make to help prevent conditions such as dementia.

The Mind diet (known as the Mediterranean-Dash Diet Intervention for Neurodegenerative Delay) was created by experts including from the Harvard Chan School of Public Health in the US.

It recommends specific "brain healthy" foods that people should eat and also lists five unhealthy food items to limit.

The healthy items suggested by the diet include: three or more servings a day of whole grains, six or more servings a week of green leafy vegetables, one or more servings a day of other vegetables, five or more servings a week of nuts, four or more portions of beans, two or more servings a week of berries, two or more meals a week of poultry and one or more meals a week of fish.

Olive oil should be the main fat used in the diet while unhealthy items should be avoided or reduced.

This means there should be fewer than five servings a week of pastries and sweets, fewer than four servings a week of red meat, less than one serving a week of cheese and fried foods and less than one tablespoon a day of butter or margarine.

In the latest study, published online in the journal Neurology, experts looked at data for 14,145 people with an average age of 64, who were followed for a decade on average.

Some 70% of those in the study were white and 30% were black and all were asked to fill out questionnaires on their diet over the past year.

Researchers looked at how closely the foods people were eating matched the Mind diet.

People were given one point for each bit of adherence to the diet (such as if they had six or more weekly servings of green leafy vegetables or five or fewer weekly servings of pastries and sweets).

The total points possible was 12.

Experts then divided the people into three groups, with the low group having an average diet score of five, the middle group having an average score of seven and the high group having an average score of nine.

Thinking and memory skills were measured at the beginning and end of the study.

Cognitive impairment (when a person has trouble remembering, learning new things, concentrating, or making decisions that affect everyday life) developed in 532 people (or 12%) in the low diet group during the course of the study.

It also occurred in 617 people (or 11%) of people in the middle group, and in 402 people (or 10%) of people in the high group.

After adjusting for factors such as age, high blood pressure and diabetes, researchers found that people in the high group had a 4% lower risk of cognitive impairment compared to those in the low group.

Women were more likely to see benefit than men, though this needs further study, researchers said.

People who most closely followed the Mind diet also declined less rapidly than those who did not, with this link stronger among black people than white.

Study author Dr Russell Sawyer, from the University of Cincinnati in Ohio and member of the American Academy of Neurology, said: “With the number of people with dementia increasing with the aging population, it’s critical to find changes that we can make to delay or slow down the development of cognitive problems.

“These findings warrant further study, especially to examine these varying impacts among men and women and black and white people, but it’s exciting to consider that people could make some simple changes to their diet and potentially reduce or delay their risk of cognitive issues.”

Previous research has suggested that the Mind diet can protect the brain by reducing oxidative stress and inflammation owing to its high levels of vitamins, carotenoids and flavonoids.

Experts say it may also reduce the risk of heart disease, diabetes and some cancers.

The study was funded by the National Institute of Neurological Disorders and Stroke and the National Institute on Aging.

Dr Jacqui Hanley, head of research at Alzheimer’s Research UK, said: “There is a wealth of evidence that eating a healthy, balanced diet can help protect our brain health. But the benefits of specific diets is less clear.

“This study adds more evidence that a Mediterranean-style diet called the Mind diet – which includes leafy greens, nuts, poultry, fish, and berries – may delay cognitive decline, including memory issues.

“However, without a detailed picture of what’s going on in the brain, we don’t know whether there is a direct link between this diet and a reduced risk of cognitive impairment. Larger and longer-term studies will be needed to understand this effect more and this should be carried out in a more diverse group of people.”

Defining XR: What It Means and How It Works

Extended reality describes virtual, augmented, and mixed-reality technologies

Extended reality sounds cutting-edge and futuristic, and in a way it is. But you might be surprised to learn that you've probably used XR without knowing it. That's because it's really just a blanket term to refer to various types of reality.

What Does XR Mean?

XR stands for extended reality. It summarizes a group of technologies—VR, AR, MR—that let you experience and interact with virtual reality, augmented reality, and mixed reality environments.

This means XR is really just an umbrella term for those experiences. Whether you're talking about a virtual reality headset or an augmented reality mobile app, what you're referring to is *extended reality*.

How Does XR Work?

Here's an overview of these three technologies:

Virtual Reality

This is arguably the most well-known XR term. Virtual reality is just that: a *virtual* view of the world, meaning it's a fully simulated 3D environment that can be interacted with in a seemingly physical way. If you're after a truly immersive experience, VR is where you want to be.

Virtual reality is often used for gaming and entertainment, but its other applications include training, education, and design.

A headset is used for VR experiences. It interrupts your normal vision to display the virtual environment, tracks your head movement, and usually includes controllers or other input devices so you can interact with the virtual world much like you would the real world.

Augmented Reality

Augmented reality covers the real world with computer-generated images and other information. Unlike VR, these virtual elements don't take over your whole vision, so you can see and interact with both the real world and the virtual items simultaneously.

AR applications include education, training, entertainment, and marketing.

You can use AR through a smartphone or a headset.

Mixed Reality

Mixed reality blends the real and virtual world in a way that lets you interact with both simultaneously. It's similar to AR, but it allows for a greater level of immersion and interaction with the virtual environment.

MR systems typically use headsets to track movements and position in the real world and to display the appropriate virtual information.

Applications of XR

Extended reality has a wide range of applications, including:

- **Entertainment**: VR and AR are used in a variety of entertainment applications, such as video games, movies, and live events. Check out these VR travel experiences for some examples.
- **Education and training**: XR technologies are used to create immersive learning experiences that allow students to explore and interact with virtual environments and simulations. Think VR flight lessons before manning the cockpit.
- **Healthcare**: Extended reality can be used in the healthcare industry for training, surgical simulations, and therapy.

- **Manufacturing and design**: XR technologies are used in the manufacturing and design process to visualize and test products before they're built. Blueprints can be scaled down to the size of a table and examined by designers for inaccuracies before implementation.
- **Marketing and advertising**: AR is used to create interactive and immersive marketing and advertising experiences. For example, a brand could use AR to let customers "try on" a new line of clothing or makeup, or visualize how furniture would look in their room next to their other décor.

Are Smart Glasses XR?

VR, MR, and AR are related terms like headsets and smart glasses. VR, and often MR and AR, are experienced through a headset. Smart glasses (at least some models) can fall into the AR category because they display virtual information next to real-world information, similar to AR smartphone apps. This makes smart glasses a form of extended reality.

Frequently asked Questions

When was virtual reality invented?

The technology surrounding the ideas mentioned above began to emerge from research started in the 1960s and 1970s. As progress on miniaturing components continues, the hope is these devices will be lighter for when you wear them over your head (VR headsets) and smaller for when you wear them on your face (augmented reality glasses). New models of headsets are coming out each year with improvements.

How does virtual reality work?

While each device will have different capabilities, they consist of sensors and screens working in conjunction to display images to your eyes based on your body's position and where you're looking. The sensors include motion detection and accelerometers, and the screens use high-resolution displays and stereo projection so the correct image is displayed to the correct eye, giving a 3D effect.

AR vs. VR vs. MR vs. XR: What's the Difference?

All augmented, virtual, and mixed reality experiences are called ‘extended reality,’ but each is different in very specific ways

If you've heard of immersive video games, virtual travel, or AR shopping, then you've no doubt run into labels like augmented reality (AR), virtual reality (VR), mixed reality (MR), and extended reality (XR). We've reviewed these terms in depth to learn what they mean and how they differ so you can have some clarity about which one is right for you.

LIFEWIRE

Overall Findings

AR	VR	MR	XR
Virtual elements overlayed on the real world.	Fully virtual experience.	Anchored virtual elements that can interact with the real world.	Umbrella term for AR, VR, and MR.
Works through a headset or smartphone.	Works through a headset.	Usually works through a headset.	
View your physical surroundings at the same time.	View only the virtual world.	View your physical surroundings at the same time.	
Can be used for free through mobile apps.	There are free apps, but they require a headset.	Can be used for free through mobile apps.	

Extended reality is a blanket term that refers to a group of technologies: augmented reality, virtual reality, and mixed reality. Therefore, a virtual reality headset and an augmented reality headset, for example, while different, are both considered extended reality technologies.

These perception-changing technologies deal with virtual elements, meaning an onboard computer generates all the objects. In VR, the CGI fully covers your vision, so you're immersed in a totally fake world. AR and MR use computer-generated images, too, but since the point is to also see your surroundings, those elements don't take over your whole vision. Instead, your physical environment is enhanced or changed in some way.

You can use some AR and MR implementations from a standard smartphone without needing headgear, but VR requires a full headset.

The rest of this article doesn't include XR in the comparison tables because it's a term used to describe the other three. It's akin to comparing computer hardware with a mouse, keyboard, and webcam.

Technology: VR Blocks Your Vision, AR/MR Doesn't

AR	VR	MR
Superimposes virtual elements on real world items.	Shows only virtual elements.	Superimposes virtual elements on real world items.

Before digging into these XR technologies, we first need to make a clear distinction between how they work. The links at the beginning of this article provide an in-depth look, but for now, you need to know that there's a single factor that separates AR and MR from VR, and that's the fact that VR totally blocks your vision.

Virtual reality is built to hide everything but computer-generated images. Augmented reality and mixed reality are built to show you the real world *and* the virtual world.

It works this way because AR and MR, as you'll read below, are designed to enhance and change what you're already doing and seeing around you, while VR is designed to replace reality with something completely fake.

Availability: AR Can Run Straight From a Phone

AR	VR	MR
Can work through a smartphone.	Requires a headset.	Usually requires a headset.

AR	VR	MR
Often free when used from a phone.	There are free apps, but only after you have the hardware.	Most useful after purchasing a headset, but it's not always necessary.

In terms of widespread availability, AR (and sometimes MR) is already in use on smartphones all over the world. By just holding your phone in front of you, you can experience things like live language translations, filters that change how your face looks in real time, and 3D models anchored in space.

Contrast this with virtual reality that's available only through a headset, and it's clear how easily accessible AR and some MR implementations are with nothing more than a smartphone. Most mixed reality experiences are accomplished through a headset, too, but with the line blurred so much between these terms, you could say some form of MR is also possible with just a phone.

Furthermore, there are plenty of free AR/MR apps, so no additional investment is needed to experience those XR types, which can't be said for virtual reality.

Immersion: VR Is the Clear Winner, MR Is Close

AR	VR	MR
You see both real and virtual elements.	Everything you see is virtual.	You see both real and virtual elements.
View simulated elements in the real world.	View and interact with fully simulated objects in a fake world.	View and interact with fully simulated objects in the real world.

An immersive experience is meant to simulate a different reality, ideally making you forget that you're even in it. VR is the only extended reality method of achieving that because you're completely engrossed in the simulated world. If you walk around in the room with your real legs, you won't know where you're going because you can't see anything but what the computer is generating (though, some VR experiences digitize real obstacles for safety reasons).

However, if you think of immersion as an altered perception where your environment is simply different from what it is usually, then MR is a close second because there's a level of interaction between the virtual and real elements, something that AR doesn't permit.

Mixed reality objects can be anchored in real space, meaning you can physically walk around them and often interact with them as if they were real. It creates a solid bridge between a completely real and a completely virtual environment.

Applications: VR/MR Excel in Education, VR in Entertainment

AR	VR	MR
Guided navigation.	Fully immersive gameplay.	3D asset collaboration.
Training exercises.	Training exercises.	Training exercises.
Real-time diagnostics.	Real-time, avatar-based socializing.	Semi-immersive gameplay.
Gaming and shopping.	Virtual movie theater and other entertainment.	Enhanced marketing.

There are lots of applications for all three XR types, and many of them bleed into the others.

AR includes your real surroundings, so it's useful for critical information in the real world, like overlaying on a body a hospital patient's vitals or X-ray details for precision surgery. Similar is MR, which isn't as helpful for a scenario like that but instead more beneficial for 'performing' the surgery with virtual objects, something that might be set up during an unqualified surgeon's training phase.

Arguably more relevant to the masses are entertainment and gaming. AR, VR, and MR create fun experiences in their own unique ways, but the deepest immersion level can be achieved only through virtual reality. With VR, an entire movie theater can be erected just for you, and realistic first-person shooter video games and virtual tourism are best enjoyed with a headset and no distractions from the outside world.

AR and MR can drastically change how we shop by letting us do all sorts of neat reality-bending tasks, like trying on clothes, testing how furniture will fit in a room, and viewing customer ratings on top of in-store products. Even VR can provide a fully simulated shopping mall for you to browse through with just a headset.

Final Verdict: They All Have Their Place

All three of these extended reality types are useful, so the one you choose depends entirely on what you want to accomplish. AR and MR are built for truly mixing real and imaginary elements, with the latter having an edge over the former by leaning deeper into the actual *mixing* of realities. VR doesn't let you view the real world around you, but that's the whole point; it excels in that you're fully immersed in a digital reality that you can enjoy alone or with friends.

If escapism and rich, life-like experiences like gaming are what you're after, you can't go wrong with VR. While MR is nearly synonymous with AR, its advantage is that it feels more real than augmented reality because you can interact with virtual elements that stay where they are regardless of how you view them. AR, however, is much more ubiquitous, available in some form on nearly all modern smartphones, often for free.

- What is Windows Mixed Reality?

  Windows Mixed Reality is a virtual- and augmented-reality framework built into Windows 10 and 11. The main hardware it uses is HoloLens 2, a set of AR glasses. WMR also runs Windows-compatible VR games like Beat Saber.

- How is augmented reality used in businesses?

  The most common way you'll see businesses use augmented reality is in mobile shopping apps. For example, you might be able to use AR to see how a piece of furniture or art will look in your home. Businesses may also use AR internally for training (e.g., projecting assembly instructions onto a workspace or identifying different work tools).

What Is Augmented Reality?

AR enriches perception with virtual elements in the physical world

The word "augment" means to increase, extend, or make better. Augmented reality (AR) can be understood as a type of extended reality (XR) where the real world is expanded or enhanced through the use of virtual elements, usually overlaying those elements on the view of the real world through the use of a visual device.

AR can work in several different ways and is used for many different reasons, but in most cases augmented reality virtual objects are overlaid on and tracked in a view of the real world, creating the illusion that they occupy the same space.

Augmented reality devices have a display, input device, sensor, and processor. These devices can be monitors, head-mounted displays, eyeglasses, contact lenses, gaming consoles, and even smartphones, among others. Sound and touch feedback can be included in an AR system, as well as through other non-visual methods and devices.

Although augmented reality is somewhat similar to other forms of XR, like virtual reality (VR), it's distinctly different. Virtual reality is an experience that's entirely simulated—both the view of "reality" and the objects in it—while AR only uses some virtual aspects, which are mixed into reality to form something different.

The term "augmented reality" was coined by researcher Tom Caudell in 1990, who helped develop the first industrial augmented reality (IAR) at Boeing.

How Augmented Reality Works

Augmented reality is live. For it to work, the user must be able to see the real world as it is right now. AR manipulates the real world space the user sees, altering their perception of reality.

In one form of AR, the user watches a live recording of the real world with virtual elements imposed on top of it. Lots of sporting events utilize this type of AR; the viewer can watch the game live from their own TV, but also see the scores overlaid on the game field.

Another type of AR allows the user to look around their environment normally and in real time, but through a display that overlays information to create the augmented experience. An example might be a headset that appears much like a regular pair of glasses, but through the screen, the user can see GPS directions on the road or sidewalk as they drive or walk, or see the current temperature in the sky when they look up.

When a virtual object is placed between the user and the real world, object recognition and computer vision can be used to allow the object to be manipulated by actual physical objects, and allow the user to interact with the virtual elements.

For example, some retailer mobile apps let shoppers select a virtual version of something they're considering purchasing, such as a piece of furniture, and view it in the real space of their home through their phone. They can see their actual living room, for example, but the virtual couch they've chosen is now visible to them through their screen, letting them decide if it will fit in that room and if they like the look of it within that room.

Another example allows customers to scan products or special codes (such as UPC symbols) that use augmented reality to show the customer more information about a physical product before they buy it, see reviews from other buyers, or check what's inside their unopened package.

Marker and Markerless AR

When object recognition is used with augmented reality, the system recognizes what's being seen and then uses that information to engage the AR device. It's only when a specific marker is visible to the device that the user can interact with it to complete the AR experience.

These markers might be QR codes, serial numbers, or any other object that can be isolated from its environment for the camera to see. Once registered, the augmented reality device might overlay information from that marker directly on the screen or open a link, play a sound, etc.

Markerless augmented reality allows a system to use a location or position-based anchor points, like the compass, GPS, or accelerometer. These types of AR systems are implemented when the location is key, such as with navigation.

Layered AR

This type of AR uses a device to recognize a physical space and then overlay virtual information on top of it. It's how you can try on virtual clothes, display navigation steps in front of you, check whether a new piece of furniture will fit in your house, put on fun tattoos, and more.

Projection AR

This might seem at first to be the same as layered or superimposed augmented reality, but it's different in one specific way: actual light is projected onto a surface to simulate a physical object. Another way to think of projection AR is a hologram.

One specific use for this kind of augmented reality might be to project a keypad or keyboard directly onto a surface, allowing a user to type using the virtual keyboard.

There are many advantages to using augmented reality in areas like medicine, tourism, the workplace, maintenance, advertising, the military, and others.

AR in Education and The Workplace

In some senses, it can be easier and more fun to learn with augmented reality, and there are tons of AR apps that can facilitate that. A pair of glasses or a smartphone can be all you need to learn more about physical objects around you, like paintings or books.

One example of a free augmented reality app is SkyView, which lets you point your phone at the sky or the ground and see where stars, satellites, planets, and constellations are located at that exact moment, both during the day, at night, and from the opposite side of the planet.

SkyView is considered a layered augmented reality app that uses GPS. It shows you the real world around you, like trees and other people, but also uses your location and the current time to teach you where these objects are located and give you more information about each of them.

Google Translate is another example of an AR app useful for learning. With it, you can scan text in a language you don’t understand, and it will translate it for you in real time. When viewed through the app on a phone, it looks like the physical space that occupies that text has changed to the target language.

Job education, too, is changing due to AR. Doug Stephen, president of CGS Enterprise Learning division, says it's becoming part of on-the-job training options.

"Often considered an emerging and disruptive technology, [AR] provides learners with an immersive format," he says. "An example of how to use consumer-focused AR for education is use of mesh modems that homeowners install to extend their internet reach. By using AR, the person can visualize the internet strengths throughout the home on a tablet or mobile device. This can alleviate in-home service (because) customer support is better enabled to see what the customer sees.

"It can also offer immediate education on set up and installation as well as help the user determine more-effective modem placements to optimize the range of the internet connections. This will ultimately help the consumer save time, effort, money and potential frustration from waiting for a technician to do in-home service."

AR in Navigation

Displaying navigation routes against a windshield or through a headset delivers augmented instructions for drivers, bicyclists, and other travelers so that they don't have to look down at their GPS device or smartphone just to see which road to take ahead. Pilots might use an AR system to display transparent speed and altitude markers directly within their line of sight for much the same reason.

Another use for an augmented reality navigation app might be to overlay a restaurant's ratings, customer comments, or menu items right on top of the building before you go inside. It might also show you the quickest route to the nearest Italian restaurant as you walk through an unfamiliar city.

GPS AR apps like Find Your Car with AR can be used to find your parked car, or a holographic GPS system like WayRay might overlay directions right on the road in front of you.

AR in Games

There are lots of augmented reality games and toys that can merge the physical and virtual world, and they come in many different forms for lots of devices. One well-known example is Snapchat, which lets users overlay fun masks and designs on their faces before sending a message. The app uses a live version of your face to put a virtual image on top of it.

Other examples of augmented reality games include Pokemon GO!, INKHUNTER, Sharks in the Park, Sketchar, Temple Treasure Hunt Game, and Quiver.

AR vs MR

Mixed reality (MR), as the name suggests, mixes real and virtual environments to form a hybrid reality. MR uses elements of both virtual reality and augmented reality to create something new. It's tough to categorize MR as anything but AR because it works similarly, by overlaying virtual elements directly onto the real world and letting you see both at the same time.

However, one primary focus with mixed reality is that the objects are anchored to real, physical objects that may be interacted with in real time. This means that MR could allow virtual characters to sit in the actual chairs in a room, or for the virtual rain to fall and hit the actual ground with life-like physics.

Mixed reality lets the user seamlessly exist in both a real state with the real objects around them and the virtual world with software-rendered objects interacting with real-world objects to create a fully immersive experience. One good example of what's meant by mixed reality is Microsoft HoloLens.

- What's the difference between AR and VR?

  Augmented reality fundamentally works and exists in the real world, adding layers of interactivity on top, like Pokémon GO. Virtual reality is full immersion in a completely virtual world, such as the survival game *Half-Life: Alyx* on the Valve Index.

- When was augmented reality invented?

  The technology that powers AR experiences was invented decades ago, but AR technology first entered the mainstream in the 1990s. AR became more popular in the 2010s due to the various AR games and products released.

Researchers determine how the hippocampus generates and sustains oscillations

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

Provided by RIKEN

Are we on the verge of an XR wearable breakthrough?

Are we on the verge of an XR wearable breakthrough?© Shutterstock

Many popular technologies today are the product of several technological and economic factors converging at the right time. A recent example is the rise of generative AI, which rapidly transitioned from an emerging technology to mainstream phenomenon, sparking revolutionary changes across various industries and societies.

Similarly, extended reality (XR), which includes augmented reality (AR), virtual reality (VR), and mixed reality (MR), has long been touted to transform immersive experiences on devices. While adoption among consumers is steadily increasing, the true impact of XR to date has been seen across a variety of business use cases, including training, manufacturing, communication, content creation and retail.

According to the PWC “Seeing is Believing Report”, the growing adoption of XR technologies across businesses could boost global GDP by US$1.5 trillion, which is nearly 2 percent of overall GDP. Through integrating XR into their processes, businesses will see significant productivity and efficiency improvements, along with substantial time and cost savings.

While challenges around wider XR adoption still exist, the tech industry is making great strides to address them, paving the way for XR to become a more mainstream technology, not just for businesses but for consumers too.

The XR challenges and how the industry is addressing them

One of the primary computing challenges with XR has always been meeting the power efficiency requirements of small wearable devices that need to be always-on. Some early XR wearable devices suffered from short battery life while untethered, limiting their practicality for extended use. The industry has responded by investing in advanced battery technologies and power management systems, leading to more efficient, longer-lasting XR wearables.

Early XR wearable devices also faced security and privacy challenges. Initially, businesses were hesitant to adopt the devices due to potential vulnerabilities in data handling and encryption. However, with the integration of enhanced encryption protocols and secure data management practices, XR devices are now far safer and more secure. The security improvements allow companies to integrate XR technologies into their operations with greater confidence, knowing that sensitive information is well-protected.

The final challenge was the lack of ecosystem support for XR technologies. Developing quality applications that met business expectations was both expensive and complex, hindering widespread adoption. Today, the industry is addressing this by creating more accessible development tools and platforms. These simplify the process of developing and deploying XR applications, enabling businesses to create tailored solutions that meet their specific needs.

Ongoing technological breakthroughs in XR

Beyond these challenges, companies are investing heavily in research and development to improve XR wearable devices and elevate the user experience. Hardware advancements, including touch screens and camera miniaturization, as well as software improvements in applications and operating systems, have created significant opportunities for XR wearable devices to become more mainstream.

AR smart glasses are one device type where there has been plenty of interesting technology innovation during the past year. For instance, Snap's fifth-generation Spectacles, Meta's next-generation Ray-Ban smart glasses, and Meta's Orion smart glasses are all examples of how XR wearables are evolving to meet business and consumer needs, with features like advanced AR displays and real-time AI video processing. More specifically, Meta's Orion glasses now offer lightweight, immersive hands-free AR, with future versions expected to add social awareness features.

Wider innovations in lightweight materials and better batteries are making XR wearable devices easier to use and wear. New AR smart glasses entering the market are now adopting ultra-thin silicon carbide waveguide technologies that not only enable high-definition displays, but also dramatically reducing the thickness and weight of the devices. This marks a significant breakthrough in AR technology. AI features are also enhancing the XR wearable device experience, making them more personalized and context aware.

How AI will transform XR Technology

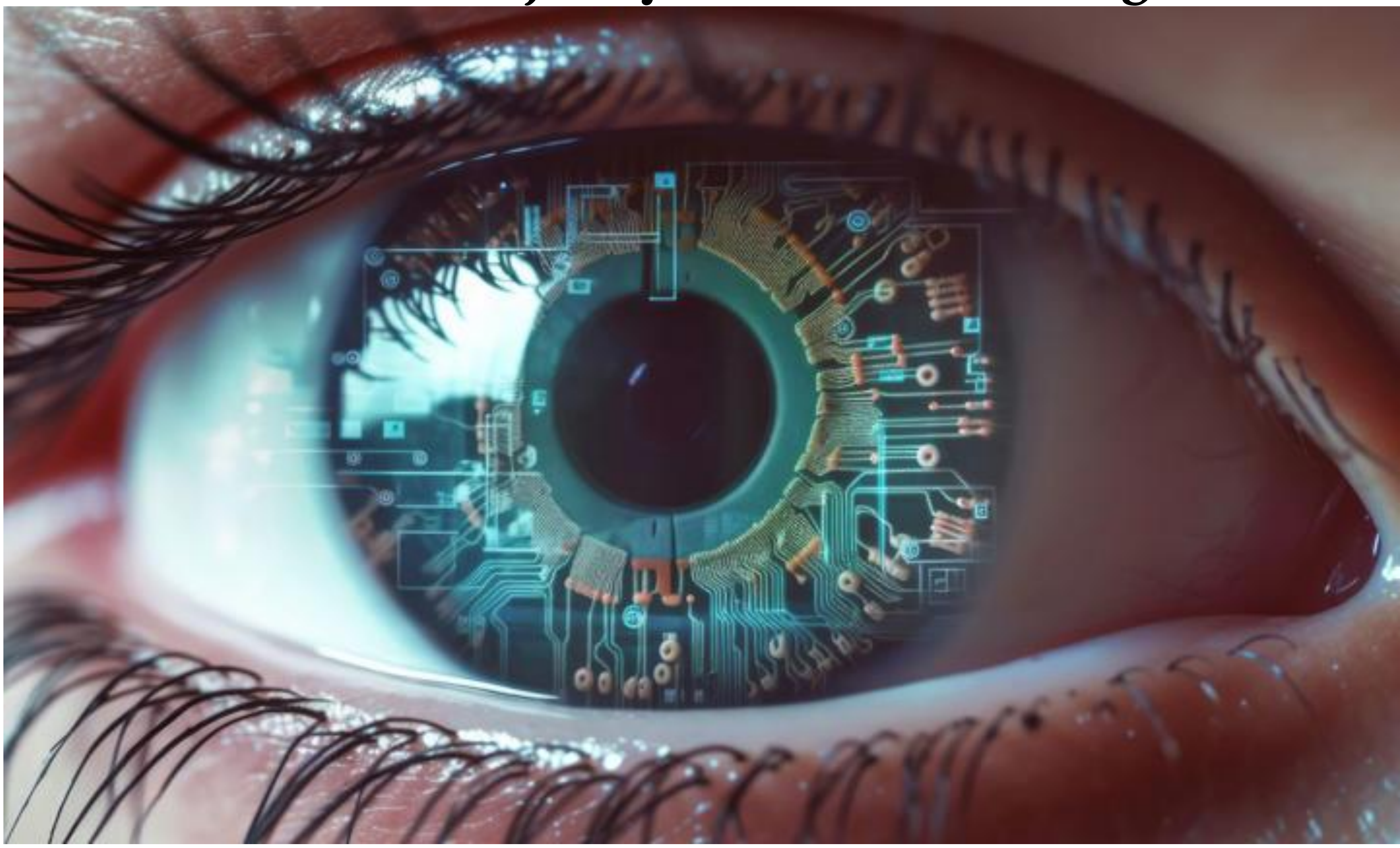
In fact, new compact language models are becoming highly influential across XR wearable technologies. These models, designed to run efficiently on smaller devices, enable real-time natural language processing and interaction, allowing users to interact with XR applications using real-time voice commands. For example, in manufacturing, workers can use a voice command to get information about assembly instructions or safety protocols without taking off their XR headsets.

Compact language models are also transforming XR experiences for consumers, businesses and healthcare, making them more immersive and interactive. For consumers, this is enabling them to create and consume new types of content via XR wearables. Meanwhile for businesses, XR wearable devices are providing employees with highly interactive real-time feedback and guidance during training. This feedback helps improve training outcomes and reduce errors, especially in manufacturing and medical sectors, leading to higher levels of efficiency and safety. Finally, in healthcare, clinicians can use XR to augment different treatments during medical procedures, reviews and training, leading to improved patient outcomes.

The next wave of digital transformation

Looking ahead, the combination of XR and AI will continue to unlock new possibilities, driving innovation across a variety of industries. With ongoing improvements in power efficiency, security and software support, and advancing technology capabilities, XR wearable devices are likely to see rising adoption among businesses and consumers. While we have yet to hit the XR tipping point, the journey ahead appears to be promising, as more consumers and businesses embark on the next wave of digital transformation.

World’s first vision-restoring stem cell treatment marks major eye care breakthrough



World’s first vision-restoring stem cell treatment marks major eye care breakthrough© Provided by Interesting Engineering

Three individuals with profoundly impaired vision who got stem-cell transplants have seen significant improvements in their eyesight that have lasted for more than a year, marking a significant advancement in the restoration of blind vision.

A fourth person with very compromised vision saw improvement, although it did not last.

These four are the first to receive transplants of reprogrammed stem cells to heal injured corneas, the eye’s clear outer surface.

The research was published on November 8 in the journal *Nature*.

Restoring vision

The findings, published in The Lancet today, are stunning, according to Kapil Bharti, a translational stem-cell researcher at the US National Eye Institute, National Institutes of Health, in Bethesda, Maryland. “This is an exciting development.”

“The results merit treating more patients,” says stem-cell researcher Jeanne Loring at Scripps Research in La Jolla, California.

The limbal ring, the dark ring around the iris, houses a reservoir of stem cells that keep the cornea’s outermost layer healthy.

When this vital source of rejuvenation is depleted—a disorder known as limbal stem-cell deficit (LSCD)—scar tissue forms on the cornea, eventually leading to blindness. LSCD can be caused by ocular damage as well as autoimmune and hereditary illnesses.

Treatments for LSCD are limited. They usually require transplanting corneal cells produced from stem cells extracted from a person’s healthy eye, which is an invasive process with questionable results.

When both eyes are afflicted, corneal transplants from deceased donors are an option; however, the recipient’s immune system may reject them.

Kohji Nishida, an ophthalmologist at Osaka University in Japan, and his colleagues made the corneal transplants using an alternative source of cells: induced pluripotent stem (iPS) cells.

They took blood cells from a healthy donor and reprogrammed them into an embryonic-like state, then transformed them into a thin, transparent sheet of cobblestone-shaped corneal epithelial cells.

Stem cell treatment

Between June 2019 and November 2020, the team enrolled two women and two men aged between 39 and 72 years old with LSCD in both eyes.

As part of the surgery, the team scraped off the layer of scar tissue covering the damaged cornea in only one eye, then stitched on epithelial sheets derived from a donor and placed a soft protective contact lens on top.

Two years after receiving the transplants, none of the recipients had experienced severe side effects. The grafts did not form tumors—a known risk of growing iPS cells—and did not show clear signs of being attacked by the recipients' immune systems, even in two patients who did not receive immunosuppressant drugs.

"It is important and a relief to see grafts were not rejected," says Bharti. But more transplants are needed to be certain of the intervention's safety, he says.

After the transplants, all four recipients showed immediate improvements in their vision and a reduction in the cornea area affected by LSCD.

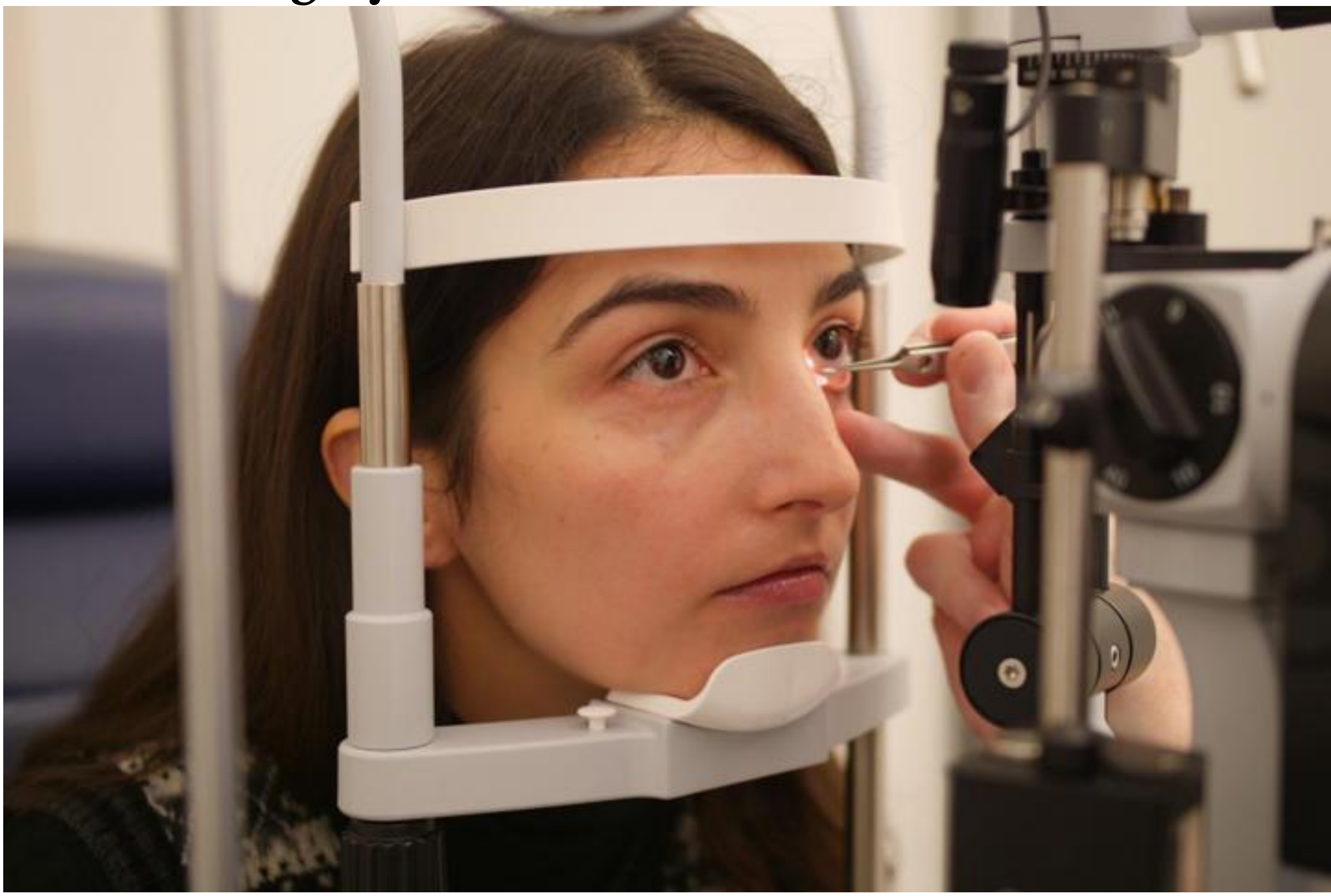
The improvements persisted in only one recipient, who showed slight reversals during a one-year observation period.

Bharti says it isn't clear what exactly caused the vision improvements. It's possible that the transplanted cells themselves increased in the recipient's corneas.

However, the vision gains could also be due to the removal of scar tissue before the transplant or the transplant triggering the recipient's cells to migrate from other eye regions and rejuvenate the cornea.

Nishida says they plan to launch clinical trials in March to assess the treatment's efficacy. Several other iPS-cell-based trials are underway globally to treat eye diseases, says Bharti. "These success stories suggest we are headed in the right direction."

Blind woman has better than 20/20 vision after AI surgery



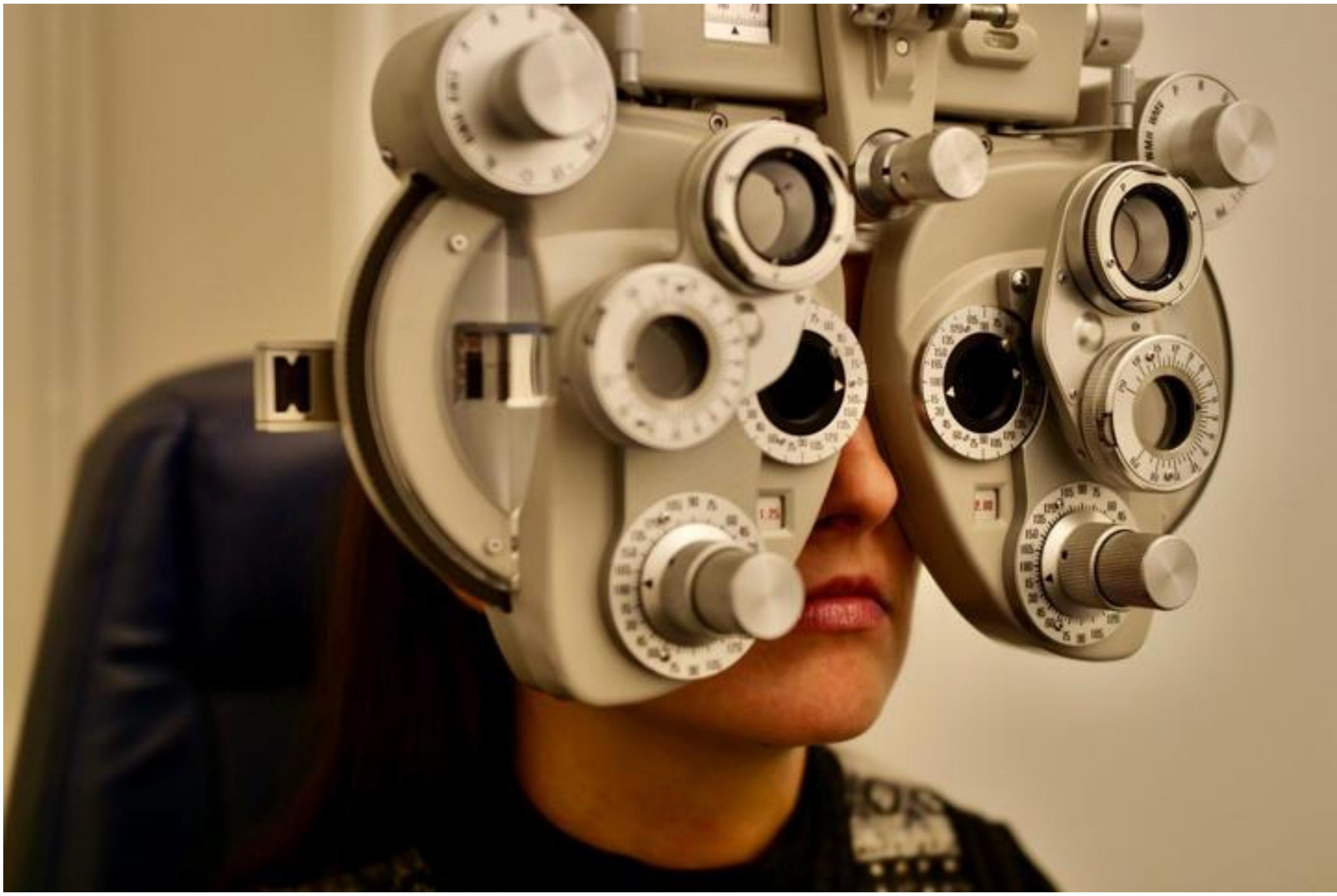
Patricia Goncalves was legally blind without glasses because of astigmatism and extreme short-sightedness

A legally blind woman now has better than 20/20 vision after becoming the first person in the UK to undergo a new type of AI-powered laser surgery.

Patrícia Gonçalves, 31, from Portugal, was the first patient in the UK to undergo the new Lasik surgery, at a private clinic in London this week.

Ms Gonçalves, who has just completed a master's degree at the University of Oxford, was legally blind without glasses because of astigmatism and extreme short-sightedness.

The procedure involved scanning her eyes and creating a digital clone of her eyeballs. An artificial intelligence program then experimented on the digital replica to create a bespoke procedure to treat Ms Gonçalves' failing eyesight. A surgeon then performed the treatment on her.



The procedure involved scanning Ms Goncalves' eyes and creating a digital clone of her eyeballs

Her £6,500 procedure on Thursday at Focus Clinics in London by chief eye surgeon Mr David Allamby was a success and she now has 20/16 vision, which is better than 20/20.

20/20 is the benchmark for eyesight and is considered to be a normal visual acuity, which is the ability to see clearly at a distance of 20ft.

"She has worn glasses since five years old, is legally blind without glasses and cannot see the huge 'E' letter at the top of the eye test chart," Mr Allamby told The Telegraph.

“Her best vision pre-op was worse than 20/200 and with glasses was just 20/20. Today, she can see 20/16, so better than 20/20, and has gained one more line down the test chart.”

The “Eyevatar” digital clone technology takes around 10 minutes to scan the eye and gather the data before a computer mimics around 2,000 different laser beams to see what will have the best impact on vision.

It has been used in China and Australia before and is now available in the UK.

“Having astigmatism, I’ve never been able to wear contact lenses comfortably, and my night vision isn’t great. I’m excited to get ray-tracing eye surgery and look forward to experiencing the results first hand,” Ms Gonçalves said ahead of her procedure.

Ms Goncalves had been excited to experience the results of the surgery

Data from a clinical trial of the technology on 200 people published last year disclosed that every single eye had better than 20/20 vision three months after the surgery.

One in 12 procedures resulted in 20/10 vision, which Mr Allamby says is “the absolute limit for a human eye” and twice as good as 20/20.

The procedure works to minimise what opticians know as the point spread function (PSF), which is the extent to which an image is distorted on the retina compared with reality.

“If you look at a point of light, the image on the retina should also be a point,” Mr Allamby explained.

“But it never is because all eyes, cameras, telescopes etc all have optical aberrations, particularly from the outer lens (or cornea in this case).

“The twin is ‘operated on’ thousands of times until the PSF is shrunk as small as possible. That is then given to the patient during Lasik.”

Hunger's Hidden "Off Switch": Newly Discovered Neuron May Hold the Key to Stopping Overeating

BY ROCKEFELLER UNIVERSITYNOVEMBER 28, 2024NO COMMENTS4 MINS READ
FacebookTwitterPinterestTelegram

SHARE


A newly identified neuron type, BNC2, quickly inhibits hunger signals in the brain, offering insights into faster satiety responses and potential obesity treatments, fundamentally altering our understanding of appetite control.

Scientists have discovered a new type of neuron, BNC2, that acts as an immediate counterbalance to hunger neurons, offering a fast-acting mechanism for satiety. This finding, which expands our understanding of appetite regulation, could lead to new treatments for obesity and metabolic disorders.

As you decide whether to eat another potato chip, a fierce battle unfolds in your brain. One group of neurons drives hunger, while another signals fullness. How quickly one side gains the upper hand determines whether you'll put down the bag of chips.

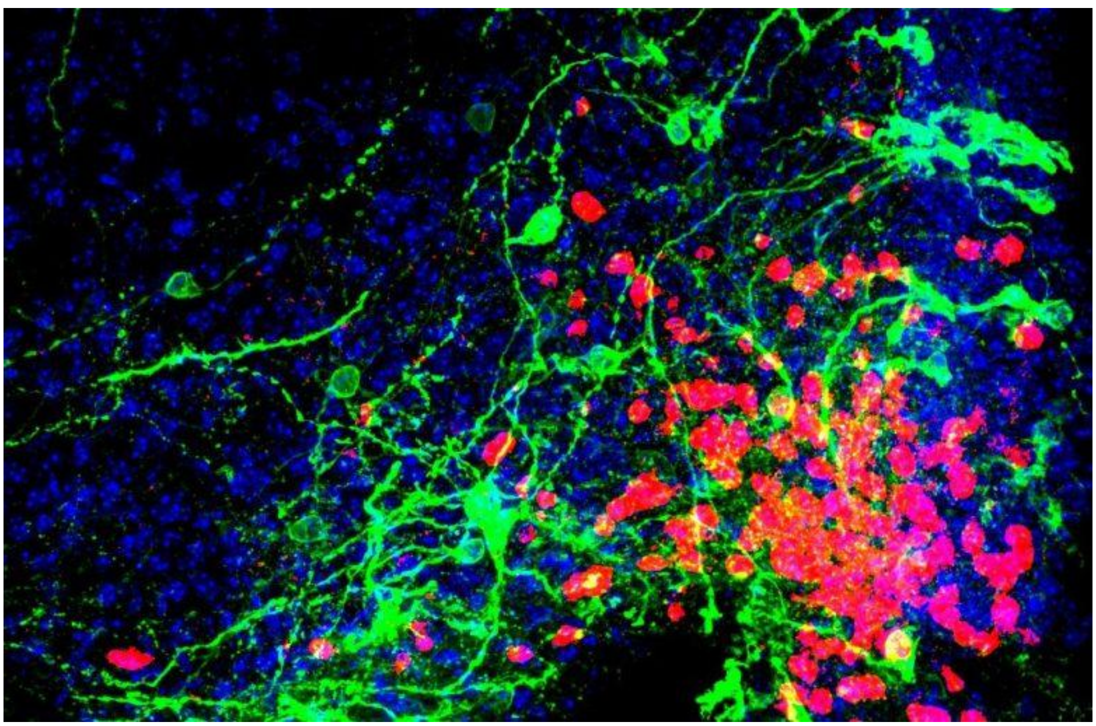
Now, scientists have discovered a missing link in this neural circuit governing hunger and satiety—a previously unidentified type of neuron that serves as an immediate counterbalance to the urge to eat. The findings, published in *Nature*, expand the classic model of hunger and satiety regulation, and may provide new therapeutic targets for tackling obesity and metabolic disorders.

"This new type of neuron changes the conceptual framework for how feeding is regulated," says Han Tan, a research associate in Rockefeller's Laboratory of Molecular Genetics, headed by Jeffrey Friedman.

More or less

Traditionally, the brain's so-called feeding circuit was thought to involve a simple feedback loop between two types of brain cells in the hypothalamus: neurons expressing a gene named AGRP drive hunger, and neurons expressing a gene named POMC promote satiety. Previously these two populations were thought to be the two main targets of leptin but recent studies suggested that this model was incomplete.

While activating AGRP neurons rapidly induces appetite, activating POMC neurons takes hours to suppress appetite. Researchers wondered whether they had missed something. "We suspected POMC couldn't counterbalance the hunger neurons quickly enough to curb feeding," Tan says. "So we wondered if there was a missing neuron that could promote rapid satiety, on a similar timescale to that of AGRP."



"Hunger" neurons expressing the AGRP gene (red), alongside newly-discovered "satiety" neurons expressing the BNC2 gene (green). Credit: Laboratory of Molecular Genetics at The Rockefeller University

Through single-cell RNA sequencing of neurons in the brain's arcuate nucleus, the team identified a new type of neuron that expresses a gene called BNC2 together with receptors for the hormone leptin, which has previously been shown to play a significant role in regulating body weight. This newly discovered BNC2 neuron rapidly responds to food cues and acts to rapidly inhibit hunger.

The findings reveal that BNC2 neurons, when activated by leptin and possibly other signals, not only suppress appetite but also alleviate the negative feelings associated with hunger. Remarkably, these neurons act by inhibiting the AGRP neurons and they can do so rapidly, serving as a complementary signal.

"This study has added an important new component to the neural circuit that regulates appetite and broadens our understanding of how leptin reduces appetite," Friedman says. "It also solves a mystery about how feeding is regulated on different time scales by different neurons."

Redefining hunger

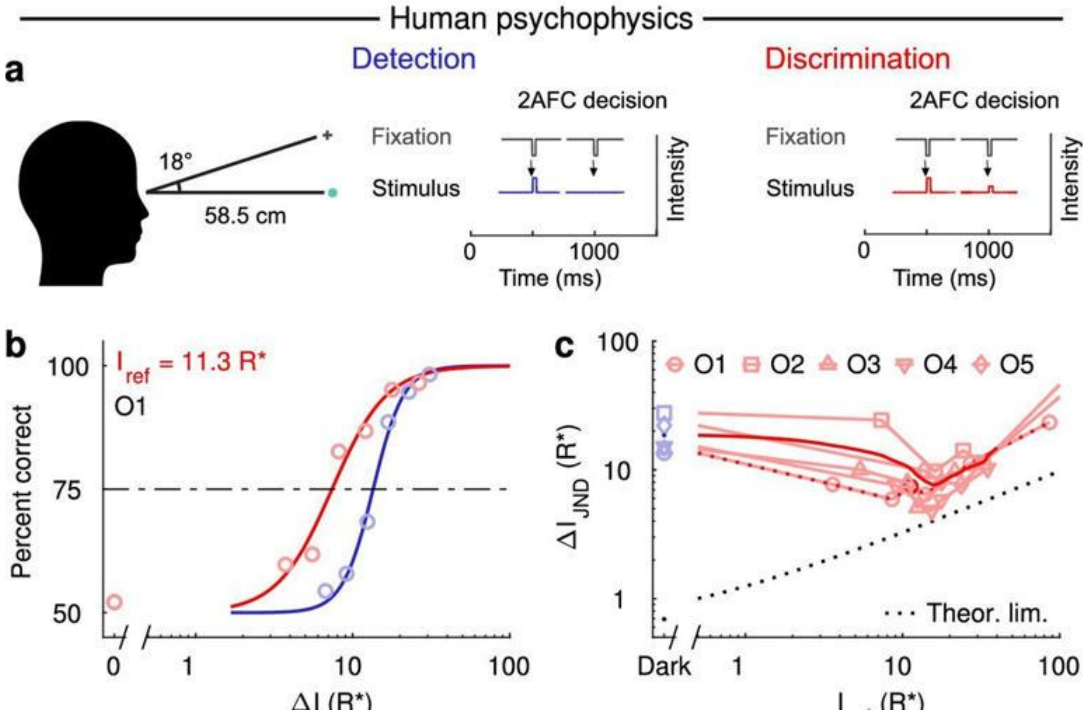
The discovery of BNC2 neurons has broad implications for tackling obesity and metabolic disorders. "We are actively researching whether targeting these neurons could provide a new therapy for obesity or diabetes," Tan says, pointing to genetic studies that link BNC2 to high body mass index and diabetes risk in patients. The team is also exploring how stimulating or inhibiting these neurons affects glucose and insulin levels, further underscoring the therapeutic potential of modulating their activity.

This discovery could also have broad implications for how we understand the brain's control over instinctive behaviors. If BNC2 neurons can coordinate hunger regulation, could there be other similar circuits for behaviors like grooming or sleeping? Identifying similar circuits could deepen our understanding of how the brain choreographs complex actions across different instinctive behaviors, paving the way for further discoveries in behavioral neuroscience.

"We now believe BNC2 and AGRP to be the sort of yin and yang of feeding," Tan says.

Reference: "Leptin-activated hypothalamic BNC2 neurons acutely suppress food intake" by Han L. Tan, Luping Yin, Yuqi Tan, Jessica Ivanov, Kaja Plucinska, Anoj Ilanges, Brian R. Herb, Putianqi Wang, Christin Kosse, Paul Cohen, Dayu Lin and Jeffrey M. Friedman, 30 October 2024, *Nature*.
DOI: 10.1038/s41586-024-08108-2
BrainNeuroscienceObesityRockefeller Uni

New research shines light on highly sensitive human visual system



The performance of human observers agrees with the new dim light detection model where performance is fundamentally limited by retinal thresholding nonlinearities along the ON pathway. Credit: Nature Communications (2024). DOI: 10.1038/s41467-024-48750-y

Researchers at the University of Helsinki have made a breakthrough in understanding what neural mechanisms allow the extreme sensitivity of human vision in darkness. The new research shows that humans can perceive minute differences in the intensity of light but that this sensitivity is achieved at the cost of the ability to detect light particles.

For nearly one hundred years, neuroscientists have pondered whether the human eye could distinguish an individual light particle, known as a photon, which is the smallest possible quantity of light. This question has been difficult to answer because it was previously impossible to accurately reconcile human visual perception and retinal activity at the extreme sensitivity conditions in darkness.

Research conducted at the University of Helsinki reveals that the human visual system sacrifices the ability to detect individual photons in order to gain greater fidelity in detecting faint lights. The research findings challenge previous conceptions of how the visual system works. The study is published in the journal *Nature Communications*.

"This research is a major step forward in visual neuroscience, providing new insight into how the human visual system functions under extreme conditions in darkness. Our study shows that the sensitivity of the human eye approaches the fundamental limits of physics, and the entire visual system performs at the absolute threshold of its capacity," says Professor Petri Ala-Laurila who led the study. He runs his two laboratories at the Faculty of Biological and Environmental Sciences at Helsinki University and at the department of Neuroscience and Biomedical Engineering at Aalto University in Finland.

"Our research shows that the human visual system has evolved to detect faint contrasts with extreme precision, which has apparently been more important than detecting individual light particles," says Dr. Markku Kilpeläinen from the University of Helsinki's Faculty of Psychology, the first author of the article.

Visual perception at the edge of darkness

The research showed that humans can detect extremely small differences in the intensity of light at the threshold of darkness. This precision is achieved thanks to the visual system's highly effective ability to eliminate what is known as neural noise. However, this means that the visual system sacrifices the ability to detect individual photons.

The researchers took accurate electrophysiological measurements of the retina and conducted observational psychological tests measuring the activity of the visual system under identical conditions at the absolute threshold of perception. This allowed them to directly connect the person's conscious visual perception to the activity of certain neurons in the retina for the first time.

"Above all, we were able to show that certain types of output neurons in the retina, known as retinal ON ganglion cells, are responsible for encoding faint light increments. This result reveals the exact division of responsibilities within the retina during a single visual task," summarizes Professor Ala-Laurila.

Implications for the development of retinal prostheses

Eye diseases typically cause changes in the neural substrate and function of the retina. Understanding how particular retinal cell types participate in encoding visual information helps to design more effective treatment methods.

The results of this research could help improve the detection and diagnosis of certain visual impairments and lay the foundations for understanding how the brain interprets the retinal code across specific cell types. This knowledge will greatly benefit developers of retinal prostheses.

More information: Markku Kilpeläinen et al, Primate retina trades single-photon detection for high-fidelity contrast encoding, *Nature Communications* (2024). DOI: 10.1038/s41467-024-48750-y

Provided by University of Helsinki

The new XREAL AR glasses are what Microsoft HoloLens should've been: on-board spatial computing takes the new 'XREAL AR One' and 'One Pro' to the next level

What you need to know

- XREAL is an augmented reality glasses company that is at the forefront of miniaturising the tech.
- Up until now, XREAL relied on external computing solutions to add spatial anchors to its insanely sharp hologrammatic screens, but not anymore.
- The XREAL One series (One and One Pro) have a new XR chip baked straight into them, side-stepping the need for apps and external add-ons.

- The XREAL One and One Pro are available now in the United States, United Kingdom, and Europe, starting at $499 USD, £449 GBP, and €549 EUR.

XREAL is back, and this time, they're even better.

I'm a big fan of XREAL. In my XREAL Air review, I detailed how the subtle lenses do all the things I wish HoloLens would've ended up doing, albeit with a key concession: they have no on-board compute. The worst thing about the XREAL glasses previously was underbaked software and integration with Windows and Android, although the app situation has improved immeasurably over time. XREAL even launched its own compute module for their glasses called the XREAL Beam, although it was a bit like carrying an extra phone around in your pocket, and not exactly ideal.

XREAL agreed, which is why their shiny new XREAL One and XREAL One Pro now have on-board computing for the first time, completing the augmented reality circle HoloLens failed to accomplish.

XREAL describes its new One series as the "biggest least forward" for consumer AR, owing to its independently-designed X1 processor platform. Previously, without a connected XREAL Beam, Android app, or Windows app, the XREAL was unable to independently reconfigure its virtual 3D display. You basically got an external monitor in glasses form, which while admittedly a very *good* external virtual reality monitor, the lack of configuration options was always a bit of a drag. Now, however, the X1 chip and the new XREAL SDK should enable an entire universe of new possibilities without having to rely on additional devices and apps to do the heavy lifting.

"Using XREAL's brand new, in-house designed X1 independent spatial computing co-processor, XREAL One Series creates a spatial display from nearly any device and for anything the wearer sees, leaping beyond the limits of today's AR and VR devices by introducing a fully customizable cinematic virtual screen that is for the first time spatially controlled by the glasses themselves."

The new glasses feature a variety of other tweaks and improvements over their predecessors. We now have speakers by BOSE, alongside official eye health certifications and even an AI-powered optional modular camera for added tracking and spatial awareness features. The new glasses have dynamic interpupillary distance control as well for the first time, which should make for a more comfortable experience and easier positioning. There are also options for prescription lenses as was the case with the previous glasses.

The XREAL glasses are compatible with a huge range of devices, giving them broad applications for all kinds of use-case scenarios. Connect them to a Steam Deck or ASUS ROG Ally for large display gaming. Connect them to a Windows PC as a second virtual monitor. Expand your Samsung S24 with Samsung DeX, and so on.

XREAL is what HoloLens could've been

The XREAL One glasses have boosted 57-degree field of view, incredibly sharp 1080p visuals, clocking in at 84 grams and 87 grams for the Pro respectively. This is orders of magnitude more usable and convenient than HoloLens, or even devices like the Meta Quest 3.

I think therein lies the big gap between what some platforms want to push vs. what consumers will actually want in reality. Yes, the XREAL aren't cheap, but they're also something I use regularly as someone who travels frequently. I watched Cyberpunk Edgerunners while travelling exclusively on the XREAL devices connected to my phone. They're great for playing Xbox Cloud Gaming titles, and also adding a bigger display to the Lenovo Legion Go and so on.

The downside was always that you couldn't resize the monitors or anchor them without extra steps. The new X1 computing platform should help resolve that situation. We'll be back with a full review soon.

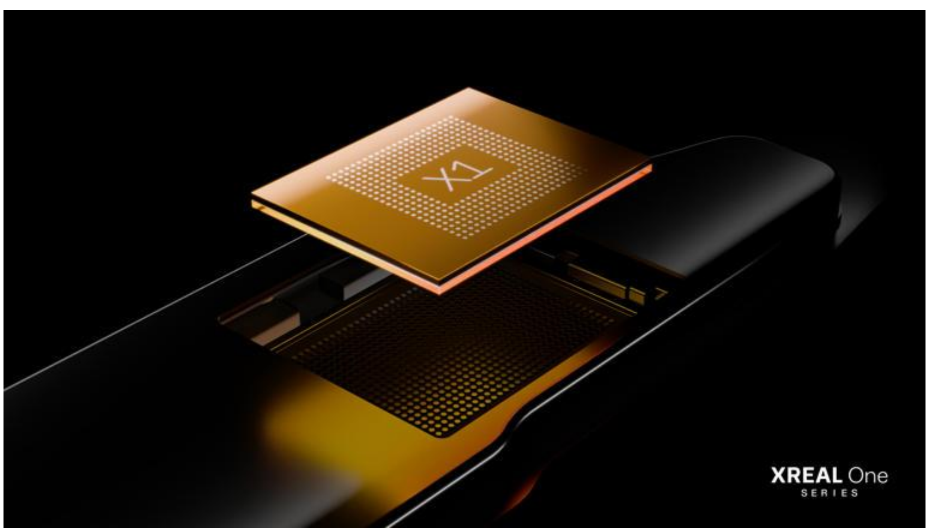
I just tried Xreal's new smart glasses and they're a leap forward for AR

Xreal already offers some of the best smart glasses in the Xreal Air 2 and today, the company announced two new smart glasses that may knock the Air 2s off the proverbial throne.

The Xreal One Series introduces a number of upgrades to it's glasses lineup, including a newly developed X1 chip that powers "independent spatial computing." The X1 enables the glasses to connect to any USB-C device creating a spatial display for gaming, work, apps and websites.

I got to give the new Xreal One and Xreal One Pro a test run a couple of weeks ago and they are impressive. We'll have a full review in the coming weeks, but here's what's new and more of my thoughts.

X1 Chip



((Image credit: Xreal))

Previously, Xreal smart glasses the like Air 2 need an accessory like the expensive Xreal Beam Pro that lets them access and create spatial displays for devices, especially ones that feature USB-C connectors with video out.

The X1 essentially takes that capability and puts it in the glasses themselves. Surprisingly, the addition of the chip doesn't really alter the way the glasses look.

"X1 powers the kind of spatial computing we’ve always envisioned and that customers have been eagerly waiting for," said Chi Xu, CEO and co-founder of Xreal.

((Image credit: Xreal))

During my test run of the One series, I was able to see the glasses connected to an iPhone 16, a Steam Deck and a MacBook. These were curated experiences but I was able to comfortably watch a YouTube video via the glasses that was outputting directly from the phone. Connecting to the MacBook enabled me to see three spatial monitors in a virtual workspace.

Both work well, with improvements to the fluidity afforded by the X1 chip and a lower latency helping especially when running a few laps in DiRT 5 on the Steam Deck. It felt very intuitive and I didn't notice any lag between the glasses and Valve's machine as I played.

Xreal says that X1 enables a "low motion-to-photon" latency of 3ms at 120Hz which is far lower than the 20ms on the currently available Air 2. And in our experience, that is especially noticeable.

Display and Design


((Image credit: Future))

Xreal has improved the display for the One and One Pro. Where the Air 2s offer 1080p per eye and 46-degree-field-of-view (FOV), the One features the same resolution with a 50-degree FOV with a larger display.

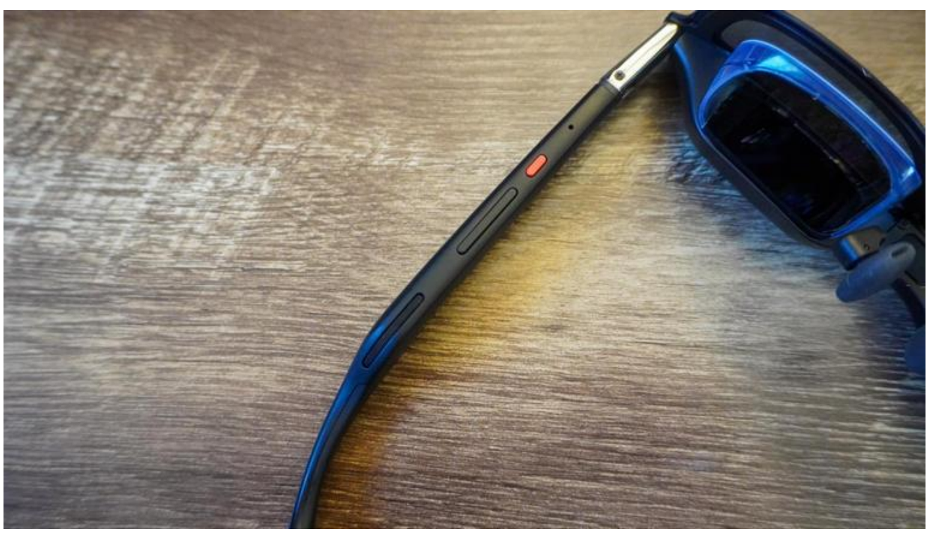
The One Pros have a 57-degree FOV, which Xreal says is the largest in the industry. They achieved this through a "flat-prism lens" that is different from the triangular birdbath design in the One and older Xreal glasses.

The new glasses are certainly more sleek than older Xreal glasses too, with silver banding at the temples and an interchangeable front frame for a customizable look. Alongside this, its dimensions are certainly a lot more low-profile, with the front of the glasses themselves being thinner too when compared to Air 2.

((Image credit: Future))

But one thing Xreal has been good to not compromise is the comfort. The Air 2 sit nicely on your face, and the One and One Pro follow suit.

The One and One Pro are listed at 84 and 87 grams (slightly heavier than the current specs). But in wearing them, I didn't feel uncomfortable with the weight, but this was only a short viewing. They did feel nicely balanced and I wasn't annoyingly aware of them like some wearable tech.



((Image credit: Future))

One cool feature that I got to hear was the new Bose speakers that are integrated into the arms of the glasses. The revs of the engine in DiRT 5 reverberate through the specs with impressive clarity, and the higher volume capability does mean you could listen to these on louder public transport with relative ease.

"Our audio tuning expertise creates a powerful and distinguished sound experience for the XREAL One Series. Content is more vibrant and lifelike, and we know consumers will hear the difference," Nick Smith, Senior VP of Strategy and Business Development for Bose said in the press release.

Xreal is also introducing a new RGB camera called the Xreal Eye that attaches to the bridge of the glasses. During my brief time with the glasses I tried on a pair with the camera attached and it didn't feel noticeably different. Though, I did not get to test out how the camera work with the One or One Pro.

Xreal says that the camera can capture "real-time" 12MP photos and record video up to 1080p at 60fps. Down the line, the camera will get multimodal AI features "including image recognition and communication via voice commands in unison with an AI or voice assistant coming from the glasses' host device."

It can be paired with the Xreal Beam Pro for augmented reality displays.

Availablity and price

((Image credit: Xreal))

Starting today, the Xreal One and One Pro are available for pre-order via the Xreal website.. The One will set you back $499/£449/€549 while the Pro One adds $100 starting at $599/£549/€649. There will also be bundles with the Xreal Beam Pro available.

If you want to get your hands on one of these sets, the One is supposed to start shipping in "mid-December" while the One Pro won't release until "early 2025."

Alibaba-backed Xreal launches augmented reality glasses with new chip as Meta rivalry heats up

- Xreal on Wednesday launched its latest generation of augmented reality (AR) glasses as it looks to fend off competition from the likes of Meta and Snap.
- The Xreal One Series features the X1 chip which is the company's first self-designed processor for its glasses and marks a big step for the product's capabilities.
- Xreal is among the companies that is betting on glasses, rather than large headsets like Apple's Vision Pro or the Meta Quest, to be the mass-market winners in AR.

The Xreal One Series features the X1 chip which is the company's first self-designed processor for its glasses.

Xreal on Wednesday launched its latest generation of augmented reality (AR) glasses as it looks to fend off competition from the likes of Meta and Snap.

The company, which is backed by Chinese e-commerce giant Alibaba, is hoping to capitalize on the growing interest in AR glasses.

The Xreal One Series features the X1 chip which is the company's first self-designed processor for its glasses and marks a big step for the product's capabilities.

Xreal talks up the ability for wearers of its glasses to be able to connect to devices such as a phone, laptop or games console, and see their content on a huge digital screen in front of them. The previous generation of Xreal's product required a companion device called the Beam for connections to a device, but the latest chip means that the Beam is not required.

"I think that it's the biggest upgrade in Xreal history and probably the biggest upgrade for the entire consumer AR glasses [sector]," Chi Xu, CEO of Xreal, told CNBC in an interview.

The X1 chip was in the works for three years, Xu said, adding that he sees it as a way to increase the capabilities of the glasses to differentiate from the competition.

"We have to step up to define a chip that is really defining some of the new features for these types of glasses," Xu said.

Xreal is one of the biggest players in the AR glasses space, but it is facing intense competition from the likes of Snap, which unveiled a new set of its Spectacles in September, as well as Facebook parent Meta's continued efforts with the Meta Ray-Ban product. Meanwhile, CNBC reported this year that Qualcomm is working on a set of glasses with Google and Samsung.

Xreal is among the companies that are betting on glasses — rather than large headsets like Apple's Vision Pro or the Meta Quest — to be the mass-market winners in AR.

"People have started to realize a headset doesn't make sense, we need to go to lighter form factors to the glasses category," Xu said. "But the challenge for glasses is can we push the limit to deliver a headset experience on a much smaller form factor?"

The Xreal One and Xreal One Pro start at $499 and $599 respectively.

AR, which refers to a technology that overlays digital content over the real world, has been hyped up over the last few years. However, the market had not exploded like many had predicted. Large headsets have proved too expensive or uncomfortable and firms including Xreal and Meta are focusing on how they can make the experience with glasses more compelling.

There is also still a lack of content and killer use cases for the product, an issue Xu said needs to change before the product category reaches a wider user base. The CEO added that this begins with good hardware.

"We need a platform, we need an ecosystem to improve the experience because we don't have any content yet. But in order to have the developers getting excited ... you need to have good hardware to begin with," Xu told CNBC.

Xu said the company is expecting to sell 500,000 units of its previous products in 2025, roughly doubling the figure of this year.

Will VR ever take off? 30 years since the first headset, it's still not there yet

Virtual reality has been close to mainstream adoption for decades, yet it remains a niche technology. While promising developments and incremental improvements continue, the game-changing app that will propel VR into every home remains elusive despite the efforts of tech giants like Meta, Google, and Apple.

History is littered with VR failures, from the early Nintendo Virtual Boy to the pricey Apple Vision Pro, but the promise of immersive digital worlds keeps companies investing billions. The stakes are high, as whoever unlocks mass-market VR will shape the future of the user experience across gaming, fitness, productivity, and beyond.

Google has been innovating in augmented reality and virtual reality for much longer than Apple

A roller coaster of hype and disappointment

VR's journey has been a roller coaster of hype and disappointment. Early attempts, like the vaporware Sega VR headset and Nintendo's ill-fated Virtual Boy, were hampered by technical limitations, high costs, and a lack of compelling content. What's worse, early VR users complained of vertigo-like symptoms.

VR didn't take off, even with the advent of more capable headsets like the Oculus Rift and HTC Vive. Google's forays into the market with Cardboard, Glass, and Daydream fizzled out, while Apple's Vision Pro stumbled with a hefty price tag and limited functionality. Meanwhile, Facebook keeps doubling down, and Samsung appears poised to re-enter the VR market. This makes us wonder who and what can succeed where capable tech companies fail.

The quest for VR's game-changing app spans three decades

VR's biggest challenge is the lack of a must-have experience that compels users to embrace the technology. While VR has shown promise in gaming, entertainment, and perhaps productivity, nothing has taken off after decades of trying.

Source:gamehistory.org
My first VR experience was in the early 90s in San Francisco. I remember donning a heavy headset and exploring an 8-bit, 3D world. It was exciting and felt innovative, but the experience didn't make me need VR in my daily life. As illustrated by the timeline below, VR's "gotta have it" application has eluded many companies in a cycle that continues to this day.

VR reached numerous milestones but never thrived

The following timeline does not capture every event or product launch in VR's history. Still, it paints a lengthy history of false starts in the seemingly forever-nascent category.

1991: Virtuality Group launches VR arcade machines. Sega announces the Sega VR headset, but it is never released.

1995: Nintendo releases the Virtual Boy, a commercial flop.

2010: Palmer Luckey creates the first prototype of the Oculus Rift.

2014: Facebook acquires Oculus for $2 billion. Sony announces Project Morpheus (later PlayStation VR). Google releases the $15 Google Cardboard.

2015: Samsung launches the Gear VR series for its Galaxy phones.

2016: The Oculus Rift and HTC Vive hit the market, marking the beginning of modern consumer VR. Google extends its VR line with the Daydream View, a sub-$100 headset that, like the Cardboard, leverages a smartphone as its brain and display. The new model incorporates fabric into the design to address comfort.

2017: Facebook launches the Oculus Go VR headset, a self-contained headset for less than $250.

2019: Google discontinues Cardboard after it fails to scale the VR market. Facebook launches the standalone Oculus Quest and updates the Oculus Rift.

2020: Google officially ends support for Daydream VR, hampered by soft demand and limited content. Facebook launches the freestanding Oculus Quest 2, which becomes a category leader at $300. Samsung ends support for its Gear VR devices and services.

2021: Facebook changes its name to Meta and promotes its metaverse to mixed reception.

2022: Meta unveils the Meta Quest Pro at $1,500. It's still available for around $1,000.

2023: Apple jumps into VR/augmented reality with the $3,500 Vision Pro headset. Meta releases its Quest 3, focusing on gaming and productivity at a more affordable $500. According to multiple sources, Mark Zuckerberg claims it's "better than the Vision Pro."

2024: Reports surface of Apple scaling back or ending Vision Pro production due to disappointing sales. No surprise there, given its eye-popping price tag.

2025: Samsung, in partnership with Google and Qualcomm, is expected to launch a new mixed-reality headset.

After a relatively dormant period in the early 2000s, the 2010s brought a resurgence of interest in VR, fueled mainly by Palmer Luckey's Oculus. Facebook's acquisition of Oculus in 2014 and Mark Zuckerberg's interest in VR amplified this excitement. This period saw the launch of high-end consumer VR headsets such as the Oculus Rift and HTC Vive. Google tried the budget angle with its $15 Cardboard, and Samsung offered its Gear VR. Since then, we've seen numerous fully standalone headsets at various price points. Despite initial buzz, these devices failed to gain widespread consumer acceptance.

Overcoming the VR content hurdle

Source: Steam
Compelling VR content is crucial to scaling the category but has been in short supply. To address this, companies adopted multiple approaches. For example, centralized platforms like the Meta Quest Store and SteamVR were created as hubs for content discovery. To expand VR's appeal to wider audiences, companies also championed the development of non-gaming experiences, spanning genres such as education, fitness, social interaction, and cinematic immersion. These efforts haven't solved the chicken-and-egg dilemma of hardware adoption and content availability.

Google keeps trying to crack the VR code

Google's attempts to conquer the VR market have been unsuccessful. Google Cardboard and Daydream View were discontinued due to low consumer adoption. On the augmented reality (AR) side, Google Glass was massively hyped and massively flopped. The company seems to have adapted its approach via its partnership with Samsung on an extended reality (an umbrella term for VR and AR) headset. The Google Play Store is rumored to be preparing to support apps for XR (extended reality) devices, indicating the growing anticipation for this technology.

Samsung takes another swing at VR

As numerous outlets have reported, Samsung is preparing to re-enter the VR market with a headset and potentially AR glasses. Samsung's platform is being developed in collaboration with Google and Qualcomm. A Samsung patent suggests the platform could reveal hidden objects in the user's field of view by overlaying digital information. Although initially expected in 2024, the launch has been delayed until 2025, and it might coincide with the Samsung Galaxy S25 debut.

Is Apple's Vision Pro heading for an exit?

Apple Vision Pro VR headset

Source: Apple

Apple launched the Vision Pro headset in 2023, positioning it as a spatial computer. Despite its advanced technology, including high-resolution displays and a powerful processor, the steep price of $3,500 put it out of reach for many consumers. Furthermore, the Vision Pro doesn't support motion controllers, a key feature for many popular VR games and applications. The high cost and limited functionality proved to be significant hurdles in attracting a wider consumer base, leading to scaled-back production and what may become the device's sunset in 2025.

Meta doubles down on VR again

Meta has long been devoted to VR and released the Quest 3 headset in 2024. The Quest 3 distinguishes itself by integrating with Windows 11. This feature positions the Quest 3 as a potential productivity tool. It will be interesting to see if this angle finds a market. Meta is also betting big on the metaverse and social experiences.

VR hurdles remain

Even if a game-changing app materializes, VR must overcome a few other barriers. Issues like the screen door effect, latency, and high component costs have improved but continue to exist.

Meta Quest 3s VR headset

Source: Meta
Let's not forget about comfort. VR headsets can feel bulky and hot and may cause eye strain for some. While motion sickness is less of an issue than it used to be, it still affects some users. Until these concerns are addressed, widespread adoption might remain out of reach.

Hope for a brighter VR future

Despite these challenges, VR isn't going away anytime soon. Companies like Meta, Google, and Samsung continue to invest heavily in VR and AR. Advancements in AI and hardware offer hope for a brighter future. However, until VR delivers compelling experiences that resonate with a wider audience, it seems destined to remain on the cusp of mainstream acceptance.

Perhaps the key to unlocking VR's potential lies in finding that elusive game-changing app, or maybe it will be a convergence of factors: compelling content that goes beyond gaming, relatively inexpensive AI-powered hardware, and comfortable, lightweight designs. Whatever the solution, one thing is clear: VR's journey to mainstream adoption continues.

LG's bizarre but impressive stretchable prototype display has the 'highest rate of elongation in the industry,' a measurement I had no idea existed

LG's bizarre but impressive stretchable prototype display has the 'highest rate of elongation in the industry,' a measurement I had no idea existed© LG Display

Flexibility could be the next bleeding edge for hardware to thread. Besides the bendy CPU whose performance leaves much to be desired outside its one party trick, monitor manufacturers are experimenting with pliable projects.

LG Display is the latest name to explore something with this technical twist, unveiling a stretchy screen prototype that can be expanded by up to 50% with a good tug (via Tom's Hardware). A prototype demonstration took place in Seoul at LG Science Park as part of a stretchable display national project during an event involving around 100 other South Korean tech stakeholders on November 8th.

This is far from the first bendy screen we've seen, with American company Corsair releasing the Xeneon Flex OLED Monitor a few years back. The big difference with LG's prototype is that it does a bit more than stretch; you can scrunch it, pull it, and twist it (though there's no word yet on whether you can bop it).

Dated reference aside (does Gen Z know the crushing low of flicking it when you mean to bop it?) LG's prototype is also a darn sight smaller than that Corsair monitor. LG's flexible display first presents RGB colour and 100 PPI at 12 inches, but can then expand up to 18-inches—which LG is quick to note in their press release exceeds "the original national project’s target of 20% elongation," and is "the highest rate of elongation in the industry."

As impressive as all of that is, I just can't get past how wrong the idea of scrunching up expensive tech feels; monitors may be hardware but they're historically not the hardiest of wares in the face of, say, a flung controller. Furthermore, in the case of the Corsair monitor, it's not just the fact you've really got to give it some welly to expand the display, but also the horrible sounds of protestation made by the frame that all contribute to the feeling of 'there's something wrong with this picture.'

Besides that, isn't the pliability of LG's prototype and its array of potential form factors just introducing heaps of new points of failure?

On the subject of durability, LG's press release states, "By using a micro-LED light source of up to 40 µm (micrometers), the new prototype's strengthened durability means it can be repeatedly stretched over 10,000 times, maintaining clear image quality even in extreme environments such as exposure to low or high temperatures and external shocks." That might be a bold claim but, if this prototype ever makes it to market in some form, it could mean cracked phone screens may one day be a thing of the past.

The LG Display prototype remains a ways off any kind of consumer environment, but the company also shared a handful of conceptual use cases. In a bid to further highlight both the prototype's durability and pliability, LG proposed a wearable application where a stretchable display panel attached to a firefighter's uniform could provide a real-time feed of information. While that could end up being a pipe dream, a wearable that actually achieves some real world good would certainly make a change.

Is this the world's first truly wearable spatial computer? Viture's Pro Neckband aims to augment AR glasses

Wearables come in many forms, from the well-established smartwatch to 2024's sleeper hit in smart rings. However, wearable computers are often limited in scope, be that due to usability or those pesky laws of physics. Yes, the Apple Watch is great, but it's still a far cry from the futuristic Pip-Boy 3000-like Sci-Fi dreams of what wearable computers could be.

However, I'd like to take this moment to welcome you to that future as today, AR Glasses maker Viture has revealed its all-new **Pro Neckband** — not just a wearable computer, but a wearable *spatial* computer that brings more of a standalone experience to the company's incredible Pro XR Glasses.

XR/AR glasses have been one of the most fascinating gadgets to track throughout 2024, especially as smart glasses increasingly find a home with mainstream audiences. These wearables bring simple mixed reality entertainment to the masses, transforming how many consume media along the way. But the Pro Neckband looks to be a major leap forward for Viture's glasses.

7 Best Black Friday smart glasses deals: Save on Ray-Ban Meta. Viture, XREAL, and RayNeo

Top-rated product

Excited about Viture's new Pro Neckband? Save $100 on the Viture Pro XR Glasses during Black Friday sales at Amazon and outfit yourself with the perfect companion to Viture's wearable wonder.

I gave these glasses a four-and-a-half star review earlier this year, and I routinely use them to play games and watch movies across their vivid 135" holographic display. It's IMAX in front of your eyes and works with mobile, tablets, Macs, and PCs to make play and productivity possible in an AR space.

Features: Built-in micro-OLED displays (1920 x 1080, 120Hz, equivalent of 135" screen at nine feet), Electrochromic dimming lenses, Harman-tuned speakers.View Deal

VITURE Pro Neckband: A very spatial wearable computer

Viture's Pro Neckband is the next step in that bold, mixed reality direction, taking the capabilities of the company's AR glasses and pairing them with the powerful backing of a portable spatial computer featuring its own AI assistant, gesture-based controls, 3DoF tracking, and some clever tech that takes advantage of the dual-screens of AR glasses to turn flat media into 3D.

Viture's Pro Neckband comes in two models: the $299 Classic, which offers 8GB of RAM and 128GB of storage, and the $399 Elite, featuring 12GB of RAM and 256GB of storage.

Both models offer the same core improvements, including a longer-lasting 3,280mAh battery, improved 6nm 8-Core CPU, Wi-Fi 6E, Bluetooth 5.2, and improvements to the Neckband's build, fans, and cooling to reduce noise, heat,


VITURE

VITURE Pro Neckband: Augmenting the AR experience

The new Viture Pro Neckband doesn't run on the same Google TV framework as Viture's original Neckband. Instead, it runs on Android and is officially certified with the Google Play Store — unlocking access to literally millions of Android apps and allowing them to run natively on-device.

Alongside this, the new Pro Neckband also features hand tracking to interact with the AR environment, which can now span multiple windows. Simple gestures can control the size of each window and the Pro Neckband also allows for similar operability as the Apple Vision Pro or Meta Quest 3/3S by using your hand to move a virtual cursor and tapping your fingers to click.

Taking things even further, the new Pro Neckband also features an AI agent, cutely dubbed Vizard — an LLM-like assistant that can answer questions, handle your schedule, and even take notes for you.

The power of AI extends beyond Vizard, and merges into your entertainment. Using AI, Viture has been able to develop a way of translating 2D media into 3D, elevating your favorite content and greatly improving the viewing experience for all. This feature is also expected to make its way to games in the future, granting you a new way to enjoy your classics.

Outlook

Alongside AR glasses makers XREAL, RayNeo, and Rokid, Viture has been paving the way for entertainment-focused smart glasses to take flight in the mainstream. While the company's AR glasses have been impressive (to say the least), the Pro Neckband aims to bring the Viture experience forward tenfold.

It's hard to get across how much of an impact something like the Pro Neckband can have on AR glasses, but a similar impact was made by XREAL with their recent Android-based Beam Pro device.

Viture's Pro Neckband looks to be taking the same steps into the next generation of wearable AR tech, stepping out even further into what's possible with the inclusion of the Vizard AI agent, creating 3D experiences from 2D media, and offering an intuitive hand-tracked method of interfacing with its AR elements.

Those interested in trying out Viture's latest Pro Neckband for themselves won't have to wait long. Pre-orders for the AR accessory are now available at the Viture Store for the $299 Classic and $399 Elite Neckband models. The Pro Neckband is expected to ship in two batches so far, with the first batch due toward the end of December, and the second batch in early January 2025.

Aside from celebrating the launch of its new Pro Neckband, Viture is also celebrating Black Friday by hosting a slew of discounts on its best AR-friendly tech. You can catch many of these sales on the Viture Amazon Storefront, and if you follow this page you'll also get a free Viture x 8BitDo Ultimate C game controller on any purchase of the Viture Pro XR glasses.

Viture's new Pro Neckband grants AR glasses extra superpowers

Viture already has some of the best smart glasses with displays currently available. However, the market is maturing, and accessories that expand capabilities are becoming important as well — which is where the company's newest release comes in: the Pro Neckband.

All The Level-ups You've Been Waiting For — Secure Your VITURE Pro Neckband on 11/26!

The Pro Neckband expands the features of Viture's smart glasses, while also adding extra battery life. The current way of using the Viture smart glasses is by using the Spacewalker app for iOS and Android, which lets Viture glasses display multiple virtual screens, browse the web, and view content, though it can't run any other apps. That limits what's possible.

The Pro Neckband changes that. It's a standalone Android device that Viture says can run "millions of apps" in a multi-window spatial computing environment. Viture describes it as "all the level-ups you have been waiting for."

Viture’s Pro Neckband is a hands-free wearable that can run Android apps. Viture

The Pro Neckband does a similar thing as Xreal’s Beam Pro, which adds advanced features found in Apple’s Vision Pro headset, as well as Rokid’s AR Lite, and includes a separate compute puck so you don’t need to connect your phone.

While VR headsets like the Meta Quest 3S borrowed AR features with advanced mixed-reality technology, Viture smart glasses paired with the Pro Neckband incorporate what was once a VR feature: hand-tracking.

To control the Pro Neckband, you simply use your hands. Viture added sensors that recognize hand gestures so you can move or resize windows and interact with apps by using wave and pinch motions.

If you’re familiar with the original Neckband, Viture says the Pro Neckband is seven times faster and has 40 times the GPU performance while being lighter and offering a longer battery life. The unnamed 6nm 8-core processor supports up to 12GB of memory, 256GB of storage, Bluetooth, and Wi-Fi 6E.

That’s plenty of RAM for its AI assistant Vizard, and enough space to load it up with your favorite games and movies. You can stream from YouTube, Netflix, and more, watching 3D movies or using Viture’s AI to turn 2D videos into 3D.

Viture

We're eager to go hands-on with this new accessory that could make Viture One and Pro smart glasses into one of the best wearable AR devices.

Check back for our full review. In the meantime, you can learn more about the Pro Neckband and preorder it now on Viture's website.

Meta Orion AR glasses could get these 3 incredible sci-fi tricks, according to new Project Aria update

- **Researchers have shared their impressive Meta Aria projects**
- **Aria is a research kit to help developers better understand AR and AI**
- **These projects could become Meta Orion features if we're lucky**

Meta has just shared an update on its Aria AR glasses research project collaborations, and they reveal some exciting potential ways that the publicly available versions of its Meta Orion AR Glasses could shape our real-world lives when they launch.

Project Aria's goal is to help software developers and researchers "better understand how to build the software and hardware necessary for future AR and AI-powered glasses." Initially an internal undertaking, Meta expanded Aria access to partners like BMW and various universities across the globe – and what they've created so far highlights some awesome use cases for AR glasses.

It's worth noting that all of these tools are still at the research stage, so we're likely still years from them being packaged into a consumer usable app – something which may not even happen with any of these projects. But they highlight some of the ways Orion could be used, and who knows? With Orion likely years away there's still plenty of time to turn these projects into the world's best AR apps before they launch.

1. Learning from the experts

The Matrix series is not a dystopian setting anyone wants to live in, but there's one aspect of that world I'm sure most of us would want to bring into our real one: the ability to download any skill we could need.

While the Orion glasses might not instantly make you a master of kung fu, or teach you how to fly a helicopter in seconds, they could help us gradually improve our skills with feedback it has learned from experts.

For its Project Aria research, the University of Bristol has been capturing data from highly skilled people – from chefs, to musicians, to athletes, to mechanics – tracking their movements and how they move objects to learn more about how they "interact with and change the world to achieve their goals."

With this understanding it's easy to see how Orion could offer AR lessons about how to repair a bike or cook a delicious meal, going so far as to highlight the real-world object you need to use and showing you how to use it in real-time.

2. Driving more safely

Researchers at IIIT Hyderabad have used Project Aria to develop its Driver Intent Prediction Project. Using the AI glasses' outward cameras, and their inward eye-tracking cams – as well as various other car sensors – the team is able to tell where drivers are looking and importantly where they aren't.

If a pedestrian mindlessly steps into the street while you're looking in your mirrors, the glasses can detect that you haven't seen them yet and warn you –

allowing you to take action. The project's goal is to reduce traffic accidents and it's easy to see how this tool could help make us safer drivers if Orion were to launch with a version of it.

3. Maximizing accessibility

The last two Aria projects demonstrate the glasses' accessibility credentials. University of Iowa researchers are using Aria to help people with hearing loss by using the specs' microphone array to help determine the direction sound is coming from. This could then be combined with prompts on an AR glasses' display, or used in conjunction with traditional hearing aids to improve its effectiveness.

Meanwhile, researchers at Carnegie Mellon University have used the glasses to help people with visual impairments. Using the glasses' sensors (and some external beacons) Aria could help people more easily navigate unfamiliar environments with real-time guidance.

These kinds of accessibility features and more are exactly how technological advancements like Meta Orion could (and should) be put to use.

As more people get their hands on Aria research kits I'm excited to see what other projects they work on, especially as that hopefully means that Orion will have some awesome tools when it eventually releases to the public.

"The most advanced pair of AR glasses ever made":Meta unveils Orion augmented reality glasses

A natural step in the progression of technology, or deeply concerning? Tech giant Meta, owner of Facebook, Instagram and more, has unveiled the first pair of what it calls "true" augmented reality (AR) glasses.

Called Orion, Meta describes the product as “the most advanced pair of AR glasses ever made.” However, they are still a prototype at present.

One of the reasons they haven’t been released to the public is not a fear that people will become even more insular than they currently are, but rather that they would cost a prohibitive $10,000 (approximately £7,900 / AU$15,600) a pair.

Orion’s hardware consists of three individual parts: the actual glasses, a wireless mouse and a wristband for gesture control.

A “feat of miniaturization,” according to Meta, Orion has the largest field of view in the smallest AR glasses form to date. “From multitasking windows and big screen entertainment to life-size holograms of people – all digital content that can seamlessly blend with your view of the physical world.”

Embedded into the wristband are electromyography sensors that capture and process electric signals generated by physical movement, and the mouse’s dual processors carry part of the computing load, including some artificial intelligence (AI), graphics rendering and machine perception.

The glasses contain custom chips that consume less power and are optimized for its functions. They’re made from magnesium, a lightweight material that efficiently dissipates heat, and miniature cameras and sensors surrounding the frame rims help the eye in hand-tracking and identifying objects in the real world. Additionally, microLED projectors beam holographic displays through the holographic lenses.

Apparently the glasses enable you to open your fridge and ask for a recipe based on what’s inside, or for some inexplicable reason “video call a friend while adjusting a digital family calendar as you wash the dishes.”

If that rather stressful-sounding scenario feels like something you’d be interested in, it’s probably best to mention how Orion looks.

Meta claims that “what makes Orion unique is that it is unmistakably a pair of glasses in both look and feel – complete with transparent lenses.”

As you can see, this is clearly not the case. They’re clunky, cartoonish, and resemble the ever-trendy 'Coke bottle' glasses style.

While just a prototype at the moment, Meta is hoping that its development team can "learn, iterate and build towards our consumer AR glasses product line, which we plan to begin shipping in the near future."

Take a look at our guides to the best AI image generators, the best 360 cameras, and the best cameras for professionals.

Meta Orion hands-on: if this is a prototype the finished product is going to be incredible.

(Image credit: Future / Lance Ulanoff)

I didn't want to love it. My plan for my first Meta Orion AR glasses experience was to dispassionately try them and quickly identify the highlights, shortcomings, and pitfalls of this not-ready-for-primetime mixed reality product. But I can't do that because I enjoyed every bit of it, almost to the point of giddiness.
Let's back up for a minute.

Meta Orion AR glasses made their global debut just weeks ago at the Meta Connect Conference on the face of company founder and CEO Mark Zuckerberg. The live demo raised eyebrows for its build, image quality, eye and gesture tracking, and smart Meta AI integration.
Orion looked like everything Google once hoped Google Glass could be and, honestly, everything Apple Vision Pro should be today.

The look like fat glasses (Image credit: Future / Lance Ulanoff)

I read some of the early hands-on' with interest and some jealousy. I've been trying AR, VR, and mixed-reality headsets, and smart glasses for well over a decade, and I sensed a tipping point in Orion. Even so, I assumed it couldn't be that good. If Meta wasn't ready to release it to the public, Orion had to be more experiment than product and the utility would be limited at best.

Meta invited me to its New York headquarters this week to wear and try Orion for myself. Since I first heard of them, it seemed like a long road to get to this moment, but to be fair, Meta's traveled far further.

You can bend some at the hinges, but I never fully collapsed them (Image credit: Future / Lance Ulanoff)

The Orion project started inauspiciously five years ago with a massive headset that was attached to a heavy backpack (see the progression below). Meta VP of Wearable Devices Ming Hua, who is also leading the Orion team, told me the joke at the time was that you had to be very strong to work on AI glasses.

Meta worked quickly in the intervening years to shrink the system. By 2022, the project, then known as Balboa, was a torn-down Quest Pro. It was only marginally smaller in 2023. It is almost miraculous that Orion made the leap from this massive and unwieldy headgear to a pair of almost fashionable magnesium glasses that weigh just under 100 grams.

This is how we got here. Yes, the guy on the left is wearing a backpack. (Image credit: Meta)

Figuring out how to shrink components, which often seems to involve building custom silicon and then spreading it throughout the body of Orion, is an achievement in and of itself. I saw an image of a see-through version of Orion, which showed virtually every square millimeter filled with circuitry, silicon, and components. Even so, Meta has yet to fit everything inside the frames.

Some supporting custom silicon lives in the wireless puck. While Meta has experimented with additional puck features like a six-degree of freedom thumb control and some cameras, during my demo, the puck sits nearby like a silent partner.

There are enough sensors built into the glasses to track eye and head movement, but Meta went a different route for Orion input. It developed an Electromyography (EMG) band that reads subtle electrical signals produced in the wrist when you perform various hand gestures. I've used some of the EMG bands in the past and they were bulky and uncomfortable. Orion's companion band is not much thicker than a sweatband and no less comfortable.

The puck has some vestigial technology that's not being used. During my demo, I never touched it. (Image credit: Future / Lance Ulanoff)

Orion's defining feature, though, may be its display system. The lenses appear mostly clear, but there's a complex interplay of tiny micro-LED projectors, silicon carbide, and waveform etching that creates a remarkably seamless AR experience.

The projectors live in the frame, sitting in stems and right next to lenses, which have a thin coating of silicon carbide, chosen for its high refraction and low image ghosting capabilities. The waveguide technology involves fine etchings on the silicon carbide surface that guide the light and imagery across the lens surfaces for a wider-than-it-sounds 70-degree field view. The resolution ends up being 13 pixels per degree (ppd).

The specs are fascinating, but the experience is what convinced me. I just got a glimpse of our AR glasses' future.

This band provides Electromyography input. If it'snot tight enough, it pickup receive the signals. (Image credit: Future / Lance Ulanoff)

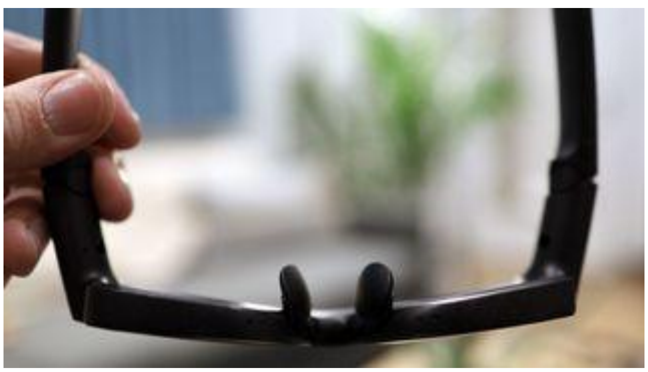
Wearing tomorrow

The first thing I noticed when they handed me the black Orion frames was that they were much lighter than expected. Yes, they are a lot thicker than, say, my glasses, but they're not actually much bigger.

When I put them on first the first time, they don't feel much different than when I'm trying to pick out a new pair of glasses. The only adjustment Meta's team insists on is finding the right nose piece. I think this has a lot to do with making sure the cameras looking at my eyes for eye tracking are in the right place. I recall Ming Hua mentioning to me that the frames use magnesium for its lightness, but also for rigidity because even a hair-width shift in the frame could set the dual displays off-axis and result in double AR vision.

Owing to this being a work in progress, some of my demos are driven and managed by a guy behind a computer. He mostly troubleshoots and reboots from afar; otherwise, I get to drive Orion.

In addition to the smart glasses, I'm fitted with an EMG band. It's positioned high on my wrist and tight enough that it can pick up my finger movements, so I can feel the haptic feedback to let me know that I've successfully transmitted a gesture instruction.



The right nose guard is important. (Image credit: Future / Lance Ulanoff)

The setup and calibration are quite similar to Apple Vision Pro in that the system asks me to, using only my eyes, look at a series of floating dots that appear in a circle in front of me. I notice right away that it doesn't seem to matter where I look, I can always see Orion's AR display. Later, I learned how to find the edges of the 70-degree FOV, but it takes effort, and in normal wear and activity, the visuals fill my view (without ever blocking them).
The system also trains me on the few gestures I'll use to access and control menus and engage with apps. Mostly, it's a pinch of the index finger and thumb or a pinch with my middle finger and thumb. I had less success with a flicking gesture that was supposed to let me scroll. Throughout my lengthy demo, the EMG band slowly slips down my wrist and eventually hangs like a bracelet. Naturally, this means it can't read any of my gestures. If I keep it high and tight on the wrist and use slightly assertive gestures, it works consistently.

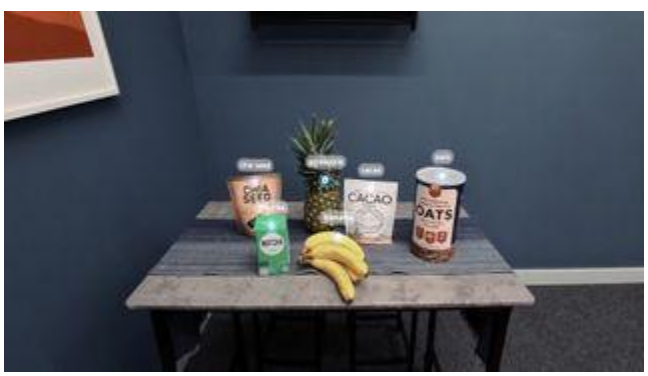
Home base

The home menu also reminds me of Vision Pro, and I reflexively pinch and grab a bar below it to bring the interface closer to me. Throughout the demo, I can't wear my glasses, which means some of the visuals are a little blurry, which is why I pulled them closer. I wondered how much better the experience would've been if I owned or had ever worn a pair of contacts.

I have several core Orion experiences, and each one was impressive in its own way.

Meta supplied mewith some b-roll images of the experiences. These images closely match what I saw. (Image credit: Meta)

When Ming Hua calls, and after I look at the call button and pinch to accept, her video call pops up in front of my face, looking much like a floating 42-inch screen. When I get up and move around, the screen stays in place. I can even look at it from the side. It really looks like part of my real world. I can see the home gesture to pull the interface in front of me. Not only is the video of decent quality, but the spatial audio, which sits near my ears, is clear. The six microphones mean I can talk in a normal tone of voice, and Hua can hear me perfectly.



Differnt room but the collection of ingredients is basically the same and, yes, I saw the labels appear right over the ingredients. (Image credit: Meta)

I stand up and walk over to a collection of ingredients, including a pineapple, cacao, bananas, whey, dates, and coconut flakes. There is a gesture to enable Meta AI, but it never works for me, so I look at the Meta AI icon and tap my fingers to access it that way.

Then I say, “Give me a recipe.” Meta AI understands this to mean that it should look at the ingredients in front of it and come up with a recipe. It’s something we do all the time without the assistance of AI.

In this instance, though, I watch as Orion identifies all the ingredients, putting little labels on each one. The 3D mapping here is spot on. Within a few moments, I have a usable recipe that I could page through. When I remove an ingredient from the table and ask for another recipe, Meta AI adjusts and gives me a coconut-encrusted banana. Yummy.

"Give me a recipe" (Image credit: Future / Lance Ulanoff)

I open Instagram, which is naturally part of the main menu, and then use a pinch and sweep-up gesture to scroll. The flick gesture doesn't work here, either. Someone messages me in another window, and when a call comes in, I look up at the call answer option, pinch my fingers, and a third window appears with a slightly unsettling-looking VR avatar of the caller. He is wearing a Quest 3s headset on his end but says that it would be two people wearing Orion glasses talking to each other with their VR avatars in the future.

Multitasking in AR is a thing. (Image credit: Meta)

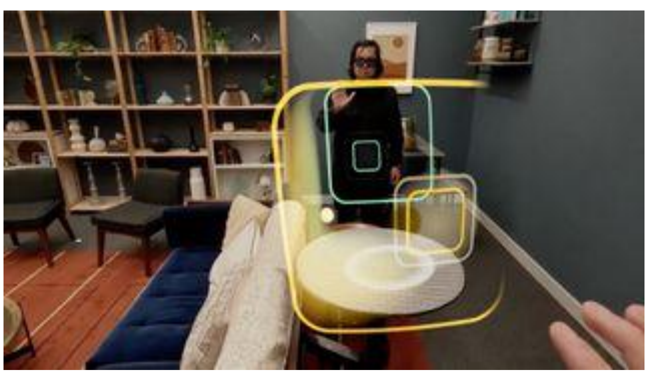
As we talk, I look around at the three screens. It’s hard to assess the image quality at the edges because, well, I’m not looking there. When I do, everything is in focus. Hua told me the system not only tracks your gaze but uses something called pupil replication, which ensures that wherever you’re looking, you still see the same image.

Put another way, the image doesn’t distort if you look at it incorrectly. I think this is what helps with the casually immersive feel of the Orion experience. I have none-too-fond memories of using Google Glass and always having to glance up and to the right to see the tiny screen. If the headset wasn’t on right, things looked weird.

I get very serious when I'm playing AR games. (Image credit: Future / Lance Ulanoff)
Orion can play games. My first experience is a space game where I steer a ship with my gaze and head movements and shoot by tapping my thumb and index finger. The game fills my field of view and is so entertaining I play all five levels and end up with a respectable 6,000+ score.

My only complaint is that I keep doing something to dump myself out of the game and into the Meta AI. I don’t know why it's happening, but I quickly return to gameplay by using the home gesture.

This multiplayer game was a lot more fun than it looks. (Image credit: Future / Lance Ulanoff)
After that, we play a multiplayer game. My opponent wears a pair of Orion glasses and stands 8 feet away from me as we play virtual ping pong. I move my virtual paddle with my open palm and bounce the translucent green ball off the walls and into his space. I don't fare as well here, though, and lose both rounds. After we play, they encourage me to step around the play area to see it from the side. My losing playfield is aglow; I reach out to touch…nothing.



Yup, this accurately represents what I saw. (Image credit: Meta)
I’ve had some concerns about the viability of Orion, especially after I heard that Meta thought they might not be able to source and scale up the manufacturer of enough silicon carbide to support mass distribution. Hua, though, seemed less sure that is the case, telling me they’d had many people in the silicon carbide manufacturing industry reach out after the reveal. The material remains very much on the list of display technology possibilities.

That's good news because I have a sense that silicon carbide plays a significant role in the wide and relatively immersive field of view. Interestingly, the base experience I just had turns out to be only one step on the way to even better Orion smart glasses in the future.

The screen resolution of the set I wore is 13ppd, but Meta already has a pair of Orion prototypes running at 26ppd, double the resolution of the first frames. They had the pair in the room and offered to let me try them out.

(Image credit: Future / Lance Ulanoff)

In one of my earlier demos, I'd opened a browser window and watched a clip from the recent Mets versus Phillies MLB division series. It looked pretty good. Now, though, on the 26ppd Orion smart glasses, there was a noticeable difference in image quality. The player's faces and the ballpark were all clearly sharper.

I realized that while everyone is talking about wearing the future, Meta is moving apace, quickly swapping and trying new components and features. Orion smart glasses that are thinner, lighter, more efficient, with a better resolution, and that cost as much (or as little) as a high-end smartphone might arrive much sooner than we think.

When I finally took off the Orion AR smart glasses after almost an hour of wearing them (they finally asked to recharge them), I was struck by how no part of my face ached. I loved my Vision Pro and Quest 3s experiences, but after 15 minutes, you know you're wearing a pound of silicon and plastic on your face. Orion felt like glasses, very, very smart and AR-capable glasses.

What if the future is almost now?

Ray-Ban Meta Smart Glasses are getting even more AI features, like live language translations and Meta AI for live video


(Image credit: Future)

The Ray-Ban Meta Smart Glasses might be the most popular smart glasses around, and that's likely thanks to their feature set and housing. Meta partnered with Ray-Ban to bring the iconic Wayfarers into the technological age with slightly thicker frames, two cameras, some speaker tech, microphones, and connectivity.

These smart glasses started out as a unique way to capture photos or videos, at times even more 'in the moment', given that you didn't need to take your phone out and launch the camera. In recent months, Meta has infused these smart glasses with Meta AI, enabling you to look at something and simply say, "Hey Meta, what's this?" and let it look, analyze it, and then provide you an answer. It's pretty neat.

Now, though, at Meta Connect 2024, the team working on the Smart Glasses wants to make these even smarter – and if you guessed that they're doing that with AI, you'd be correct.

Language translations and visual reminders

Kicking things off with what might be the most helpful new feature, the Ray-Ban Meta Smart Glasses will get live language translation later this year. Similar to what Samsung accomplished with the Galaxy Buds Pro 2 or Google with the Pixel Buds Pro 2, the Ray-Ban Metas will be able to translate languages near-live, initially between English and Spanish, Italian, and French.

This could prove pretty helpful, and more natural than attempting to do this with earbuds in, as it's baked into the smart glasses, which you might already be wearing daily if you've opted to install prescription lenses.

Furthermore, beyond asking Meta to set a reminder verbally, you can now set up reminders based on things that you see, and therefore Meta is viewing – so it could be as you're getting milk out of the fridge and realize you're almost out, or maybe a package that you left near your front door that you need to be sure you take with you. This feature should be rolling out sooner rather than later.

Similarly, you'll now be able to scan QR codes for events, phone numbers, and even full contact information. If a QR code is visible, you'll be able to ask Meta via the Ray-Ban Meta Smart Glasses to scan it – we imagine the information will then appear in the Android or iOS companion app.

Get the best Black Friday deals direct to your inbox, plus news, reviews, and more.

Sign up to be the first to know about unmissable Black Friday deals on top tech, plus get all your favorite TechRadar content.

Contact me with news and offers from other Future brandsReceive email from us on behalf of our trusted partners or sponsors
By submitting your information you agree to the Terms & Conditions and Privacy Policy and are aged 16 or over.

An ambitious video step

Likely the most ambitious forthcoming feature, also set to arrive later this year, Meta AI for video, meaning that Meta can view what you're looking at in real time, not just an image snapshot, and provide clarity or answer questions. This could be helpful for navigating around a city, cooking a meal, completing a math problem, or helping you finish a Lego set.

This is likely a big step and would raise some privacy concerns, as it's a live view from your glasses that's being processed immediately. You'll also need the Ray-Ban Meta Smart Glasses to be connected to the internet via an iPhone or Android for this to work, as it would need to process the information in real time.

Still, though, it does likely give us an idea of where Meta is headed with the smart glasses category, and it's great to see that Meta is continuing to roll out new features to the smart glasses. And that's the good news here – these updates don't, so far as we know, require new hardware. These are set to arrive as over-the-air updates for folks who already have the Ray-Ban Meta Smart Glasses, or who purchase them.
Another update that's on the way is integration with Amazon Music, Audible, iHeart, and Spotify integration, which will give you easier access to your favorite songs, artists, podcasts, and books hands-free. You'll also see new Transition lens options arriving from EssilorLuxottica, the eye giant behind brands ranging from Dolce & Gabbana to Oakley.
So, if you haven't loved the available looks enough to get a pair yet, or want to freshen yours up, once those hit the scene it'll a good time to consider them again. We'll be going hands-on with these new features, from language translation to Meta AI for video, as soon as we can, so stay tuned to TechRadar.

Startup’s displays engineer light to generate immersive experiences without the headsets

“We are adding a new layer of control between the world of computers and what your eyes see,” says Barmak Heshmat, co-founder of Brelyon and a former MIT postdoc.

Zach Winn | MIT News

Publication Date:
September 12, 2024

“Wherever you want to increase visual efficiency with screens, Brelyon can help,” Barmak Heshmat says.

One of the biggest reasons virtual reality hasn’t taken off is the clunky headsets that users have to wear. But what if you could get the benefits of virtual reality without the headsets, using screens that computationally improve the images they display?

That's the goal of the startup Brelyon, which is commercializing a new kind of display and content-rendering approach that immerses users in virtual worlds without requiring them to strap goggles onto their heads.

The displays run light through a processing layer before it reaches users' eyes, recalculating the image to create ultrawide, visual experiences with depth. The company is also working on a new kind of content-rendering architecture to generate more visually efficient imagery. The result is a 120-inch screen that simulates the sensation of looking out a window into a virtual world, where content pops in and out of existence at different angles and depths, depending on what you feed the display.

"Our current displays use different properties of light, specifically the wavefront of the electric field," says Brelyon co-founder and CEO Barmak Heshmat, a former postdoc in the Media Lab. "In our newest architecture, the display uses a stack of shader programming empowered with inference microservices to modify and generate content on the fly, amplifying your immersion with the screens."

Customers are already using Brelyon's current displays in flight simulators, gaming, defense, and teleoperations, and Heshmat says the company is actively scaling its manufacturing capacity to meet growing demand.

"Wherever you want to increase visual efficiency with screens, Brelyon can help," Heshmat says. "Optically, these virtual displays allow us to craft a much larger, control-center-like experience without needing added space or wearing headsets, and at the compute level our rerendering architectures allow us to use every bit of that screen in most efficient way."

Of light and math

Heshmat came to MIT in 2013 as a postdoc in the Media Lab's Camera Culture group, which is directed by Associate Professor Ramesh Raskar. At the Media Lab, Heshmat worked on computational imaging, which he describes as "combining mathematics with the physics of light to do interesting things."

With Raskar, Heshmat worked on a new approach to improving ultrafast cameras that used time as an extra dimension in optical design.

"The system essentially sent light through an array of mirrors to make the photons bounce many times inside the camera," Heshmat explains. "It allowed us to capture the image at many different times."

Heshmat worked across campus, ultimately publishing papers with five different professors, and says his experience at MIT helped change the way he perceived himself.

"There were many things that I took from MIT," Heshmat says. "Beyond the technical expertise, I also got the confidence and belief that I could be a leader. That's what's different about MIT compared to other schools: It's a very vibrant, intellectually-triggering environment where everyone's very driven and everyone's creating their own universe, in a sense."

After graduating, Heshmat worked at a virtual reality company, where he noticed that people liked the idea of virtual reality but didn't like wearing headsets. The observation led him to explore ways of achieving immersion without strapping a device to his head.

The idea brought him back to his research with Raskar at MIT.

“There’s this relationship between imaging and displays; they’re kind of like a dual of each other,” Heshmat explains. “What you can do with imaging, the inverse of it is doable with displays. Since I’d worked on this imaging system at MIT, what’s called time-folded imaging, I thought to try the inverse of that in the world of displays. That was how Brelyon started.”

Brelyon’s first check came from the MIT-affiliated E14 Fund after Heshmat built a prototype of the first device in his living room.

Brelyon’s displays control the angles and focus of light to simulate wide, deep views and give the impression of looking through a window. Brelyon currently sells two displays, Ultra Reality and Ultra Reality Mini. The Ultra Reality display offers a 10-foot-wide display and a depth of around 3 feet. The displays are fully compatible with standard laptops and computers, so users can connect their devices via an HDMI cable and run their favorite simulation or gaming software right away, which Heshmat notes is a key benefit over traditional, headset-based virtual reality displays that require companies to create custom software.

“This is a plug-and-play solution that is much smaller than setting up a projection screen, doesn’t require a dedicated room, doesn’t require a special environment, doesn’t need alignment of projectors or any of that,” Heshmat says.

Processing light

Heshmat says Brelyon has sold displays to some of the largest simulation training companies in the world.

"In simulation training, you usually care about large visualizations and large peripheral fields of view, or situational awareness," Heshmat says. "That allows you to look around in, say, the cockpit of the airplane. Brelyon allows you to do that in the size of a single desktop monitor."

Brelyon has been focused on selling its displays to other businesses to date, but Heshmat hopes to eventually sell to individuals and believes the company's displays hold huge potential for anyone who wants to improve the experience of looking at a monitor.

"Imagine you're sitting in the backseat of a car, and instead of looking at a 12-inch tablet, you have this 14-inch or 12-inch aperture, but this aperture is looking into a much larger image, so you have a window to an IMAX theater," Heshmat says.

Ultimately, Heshmat believes Brelyon is opening up a new platform to change the way we perceive the digital world.

"We are adding a new layer of control between the world of computers and what your eyes see," Heshmat explains. "We have this new proton-processing layer on top of displays, and we think we're bridging the gap between the experience that you see and the world of computers. We're trying to connect that programming all the way to the end processing of photons. There are some exciting opportunities that come from that. The displays of future won't just let the light out just like an array of lamps. They'll run light through these photon processors and allow you to do much more with light."

Neuroscientists discover interactions between brain waves and nerve cells during human memory processes

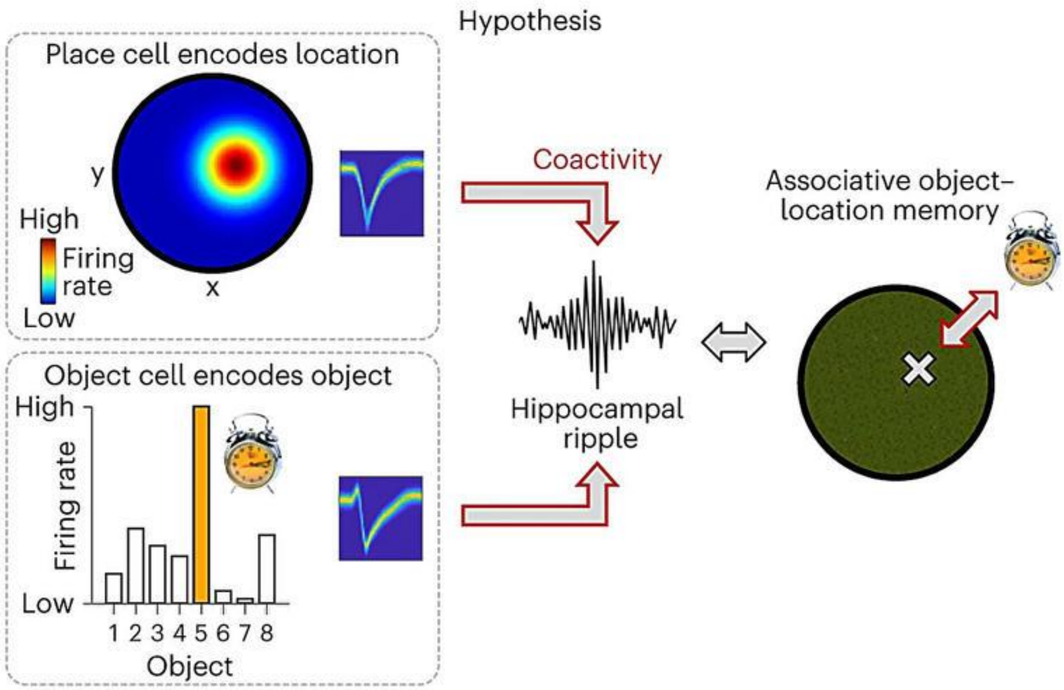


Illustration of the hypothesis that human associative object–location memory is linked to the coactivity of object cells and place cells during hippocampal ripples. We propose that the coactivity is specific to pairs of object and place cells that encode 'associative information', which are those cell 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

.

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

Provided by University Hospital of Bonn