Making words of thoughts

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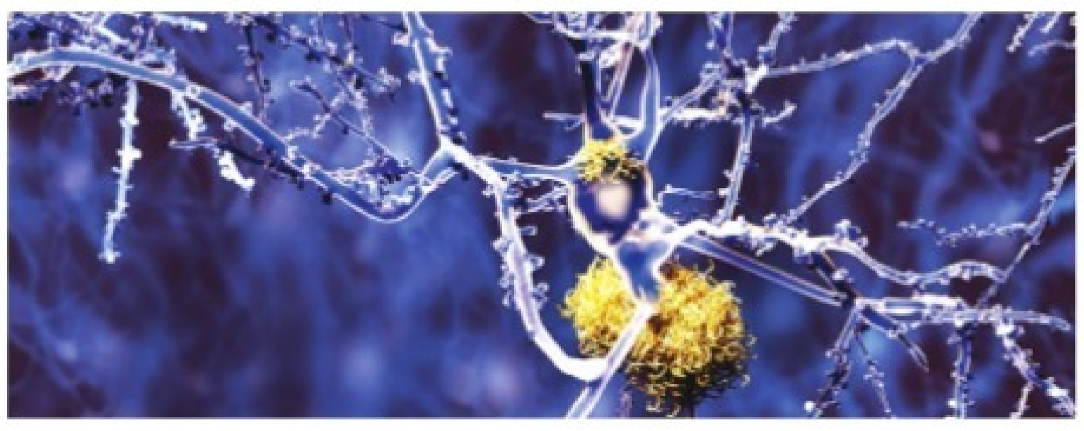
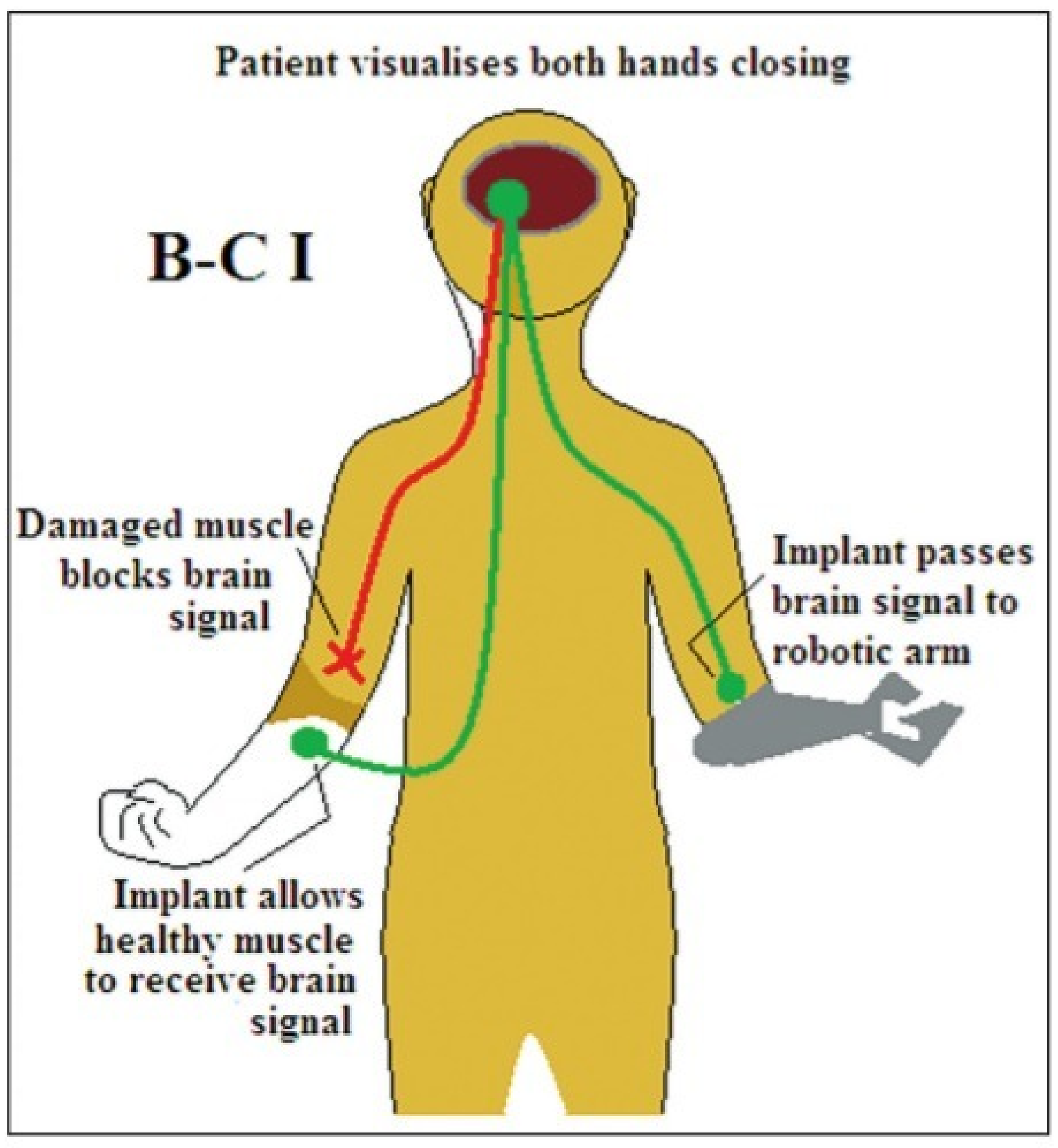
People who have lost most of their muscle function may still be able to speak





Not being able to speak may be worse than other forms of paralysis as it affects the ability to communicate. Affected people usually devise a way to spell out the words they want to say and are able to stay productive. Patients of strokes or ALS (see box) or other diseases that compromise speech, for instance, may use a keyboard, if it is possible. And when the fingers cannot work a keyboard, there is technology where movement of the pupil of the eye is tracked to identify letters. The patients can then use a computer and the celebrated Stephen Hawking could address audiences with the help of a voice synthesiser.

Things get serious when patients lose the ability to move the pupils of the eyes. Even communicating personal needs or a medical condition then become challenges. A technology called Brain-computer Interface, or BCI, could then come to the rescue. This technology was first used to help patients who had lost the ability to work a limb, because a nerve was severed, by connecting the part of the brain that controlled the limb directly to the muscles. If the limb itself had been lost, the signal from the brain could work a robotic limb. The technology was then adapted to read brain signals in the form of letters of the alphabet and display the letters on a screen. A user could then think, or mime the names of letters and type out a message.

These methods, of course, are much slower than normal speech. Spelling out a message at a speed of eight words in a minute is considered good going, but not compared to around 150 words a minute in the case of normal speech. A group working in California, however, reports a breakthrough where brain signals directly produce spoken sentences, without going through the route of spelling and synthesis. Gopala K Anumanchipalli, Josh Chartier and Edward F Chang, from the University of California at San Francisco and at Berkley write in the journal, *Nature*, that they have succeeded in tapping into the nerve signals in the brain, which activate the jaws and the larynx for normal speech, and then to use artificial intelligence to generate audio signals of speech itself.

The reason that AI has to be used is that the sequence through which brain signals are translated into speech is too complex to negotiate by ordinary means. A commentary on the University of California paper says the process "requires precise, dynamic coordination of muscles in the articulator structures of the vocal tract — the lips, tongue, larynx and jaw." The paper itself says over a hundred muscles are involved and the movements and sounds are not connected in a simple way. In place of working out how all this works in practice, the method used is simply to collect sets of nerve signals and seek patterns in the signals that correspond to components of actual speech.

This is the same approach, trial and error, which helps a human infant learn speech through the muscle manipulations that result in different sounds. Whenever a random series of nerve impulses produces a successful result, the pathways followed by impulses get strengthened. Over a period of trials, the feedback due to success ensures that the specific neural network that leads to a given sound is used when that sound is desired.

Artificial Intelligence uses the same framework to "train" a computer to "learn" tasks. This replaces the need to develop complex, and often impossible, computer programmes for the same purpose. Typically, a brace of inputs, say nerve signals, result, repeatedly, in random outputs, which generate different sounds. Whenever a correct sound is generated, the probability that particular outputs result from the set of inputs is increased. The outcome, after several trials, is that the combination of outputs that lead to correct sounds, given certain inputs, becomes the most likely, and finally the only ones that are produced. The system could then be said to have learnt to generate specific audio outputs in response to nerve signals that are fed to the system. Based on learning by trial and error, in this way, artificial intelligence methods have trained computers to carry out complex tasks, play chess, diagnose diseases, make market projections and even drive cars.

In the current work, the researchers used probes to access the brain signals of a set of volunteers. The signals were from the parts of the brain which control speech and the related muscles, and at the time the volunteers spoke different sentences. From the set of brain signals recorded while the different sounds are made, there are methods to go from the signals to synthesising the same speech. The current group, however, used a two-step method, first estimating movements in the anatomical structures involved in speech, which the signals evoked.

This decoding of the brain signals was carried out based on large existing data of the muscle movements associated with known speech recordings. Using this data, the system was trained to associate the anatomical movements associated with brain signals when the volunteers spoke, or even only mimed speech. And then, actual speech was synthesised based on the anatomical movements estimated.

The paper says that testing the intelligibility of the speech produced showed the synthesised speech could be fairly accurately made out. The two-step method side-stepped the need to collect large brain-signal-to-speech data for training brain signals directly to speech. A significant observation is that the system could be trained even without the subjects having to actually speak, they could just mime speech, to generate the required brain signals. This is significant because it may be possible for the system to be effective with patients who have lost the ability to speak, on the basis only of signals in the brain cortex when the patient imagines that she is speaking. While the paper cautions that the work, so far, is only a "proof of concept", it does point to ways of improving the quality of life of affected people.

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What is ALS?

ALS stands for Amyotrphic Lateral Sclerosis. "A" is a Greek prefix for no, "myo" refers to muscle, and "trophic" means nourishment. "Lateral" is the part of the spinal cord which controls muscles and movement, and "Sclerosis" means hardening or damage.

ALS thus leads to a breakdown of communication from the brain to the muscles. Patients progressively lose the ability to move, eat, speak and even breathe. There is no cure known so far, but there are drugs that retard the progress of the disease to some degree.

Concrete plan of action

To solve climate change and biodiversity loss, we need a 'Global Deal for Nature'. Here's why and how it needs to be executed

GREG ASNER

Earth's cornucopia of life has evolved over 550 million years. Along the way, five mass extinction events have caused serious setbacks to life on our planet. The fifth, which was caused by a gargantuan meteorite impact along Mexico's Yucatan coast, changed Earth's climate, took out the dinosaurs and altered the course of biological evolution.

Today Nature is suffering accelerating losses so great that many scientists say a sixth mass extinction is underway. Unlike past mass extinctions, this event is driven by human actions that are dismantling and disrupting natural ecosystems and changing Earth's climate.

My research focuses on ecosystems and climate change from regional to global scales.

In a new study titled "A Global Deal for Nature," led by conservation biologist and strategist Eric Dinerstein, 17 colleagues and I lay out a road map for simultaneously averting a sixth mass extinction and reducing climate change.

We chart a course for immediately protecting at least 30 per cent of Earth's surface to put the brakes on rapid biodiversity loss, and then add another 20 per cent comprising ecosystems that can suck disproportionately large amounts of carbon out of the atmosphere.

In our view, biodiversity loss and climate change must be addressed as one interconnected problem with linked solutions.

Let's make a deal

Our "Global Deal for Nature" is based on a map of about a thousand "ecoregions" on land and sea, which we delineated based on an internationally growing body of research. Each of them contains a unique ensemble of species and ecosystems, and they play complementary roles in curbing climate change.

Natural ecosystems are like mutual funds in an otherwise volatile stock market. They contain self-regulating webs of organisms that interact. For example, tropical forests contain a kaleidoscope of tree species that are packed together, maximising carbon storage in wood and soils.

Forests can weather natural disasters and catastrophic disease outbreaks because they are diverse portfolios of biological responses, self-managed by and among co-existing species. It's hard to crash them if they are left alone to do their thing.

Man-made ecosystems are poor substitutes for their natural counterparts. For example, tree plantations are not forest ecosystems — they are crops of trees that store far less carbon than natural forests, and require much more upkeep. Plantations are also ghost towns compared to the complex biodiversity found in natural forests.

Another important feature of natural ecosystems is that they are connected and influence one another. Consider coral reefs, which are central to the "Global Deal for Nature" because they store carbon and are hotspots for biodiversity. But that's not their only value — also protect coasts from storm surge, supporting inland mangroves and coastal grasslands that are mega-storage vaults for carbon and homes for large numbers of species. If one ecosystem is lost, risk to the others rises dramatically. Connectivity matters.

The idea of conserving large swaths of the planet to protect biodiversity is not new. Many distinguished experts have endorsed the idea of setting aside half the surface of the Earth to protect biodiversity. The Global Deal for Nature greatly advances this idea by specifying the amounts, places and types of protections needed to get this effort moving in the right direction.

Building on the Paris Agreement

We designed our study to serve as guidance that governments can use in a planning process, similar to the climate change negotiations that led to the 2015 Paris Agreement. The Paris accord, which 197 nations have signed, sets global targets for cutting greenhouse gas emissions, provides a model for financial assistance to low-income countries and supports local and grassroots efforts worldwide.

But the Paris Agreement does not safeguard the diversity of life on Earth. Without a companion plan, we will lose the wealth of species that have taken millions of years to evolve and accumulate.

In fact, my colleagues and I believe the Paris Agreement cannot be met without simultaneously saving biodiversity. Here's why — the most logical and cost-effective way to curb greenhouse gas emissions and remove gases from the atmosphere is by storing carbon in natural ecosystems.

Forests, grasslands, peatlands, mangroves and a few other types of ecosystems pull the most carbon from the air per acre of land. Protecting and expanding their range is far more scalable and far less expensive than engineering the climate to slow the pace of warming. And there is no time to lose.

Worth the cost

What would it take to put a "Global Deal for Nature" into action? Land and marine protection costs money — our plan would require a budget of some US$100 billion per year.

This may sound like a lot, but for comparison, Silicon Valley companies earned nearly $60 billion in 2017 just from selling apps. And the distributed cost is well within international reach. Today, however, our global society is spending less than a tenth of that amount to save Earth's biodiversity.

Nations will also need new technology to assess and monitor progress and put biodiversity-saving actions to the test. Some ingredients needed for a global biodiversity monitoring system are now deployed, such as basic satellites that describe the general locations of forests and reefs. Others are only up and running at regional scales, such as on-the-ground tracking systems to detect animals and the people who poach them, and airborne biodiversity and carbon mapping technologies.

But key components are still missing at the global scale, including technology that can analyse target ecosystems and species from Earth orbit, on high-flying aircraft and in the field to generate real-time knowledge about the changing state of life on our planet. The good news is that this type of technology exists, and could be rapidly scaled up to create the first-ever global nature monitoring programme. Technology is the easier part of the challenge. Organising human cooperation toward such a broad goal is much harder. But we believe the value of Earth's biodiversity is far higher than the cost and effort needed to save it.

The writer is director, Center for Global Discovery and Conservation Science, and Professor, Arizona State University, US. This article first appeared on www.theconversation.com

PLUS POINTS

Faster than thought

The universe is expanding considerably faster than it should be, Nasa has confirmed. The space agency's Hubble Space Telescope shows that it is growing about nine per cent faster than had been expected, based on the trajectory it started with shortly after the Big Bang, according to astronomers. While such a discrepancy had already been suggested, the new measurements reduce the chance this is a mistake to just one in 100,000.

Such a confirmation could require astronomers to find new physics theories to explain the universe's strange behaviour. "This mismatch has been growing and has now reached a point that is really impossible to dismiss as a fluke. This is not what we expected," says Adam Riess, Bloomberg Distinguished Professor of physics and astronomy at Johns Hopkins University, Nobel laureate and the project's leader.

The speed of the universe's expansion, known as the Hubble constant, is a central part of physics and our understanding of the universe. But it has repeatedly been observed to behave unexpectedly — the more astronomers find out about it, the more wrong it appears — in ways that have forced scientists to wonder whether our assumptions about it had been wrong.

The new research saw Riess and his team analyse light from 70 stars in a galaxy near ours, known as the Large Magellanic Cloud, using a new method that allowed them to capture the stars quickly. The stars they observed are called Cepheid variables, and change brightness predictably, allowing them to be used to measure intergalactic distances.

The new method allowed the researchers to measure many more of those stars far more quickly. Normally, Hubble can only look at one star each time it takes one of its 90-minute orbits around Earth, but the new method allowed it to see dozens in that same time.

Using that data, the researchers were able to confirm our understanding of the "cosmic distance ladder", which allows us to determine distances throughout the universe. And they were able to use the information to calculate the Hubble constant, and see how fast the cosmos is expanding.

The more precise that understanding became, the clearer it was that the speed was not in line with what they expected.

The Independent

Balancing selection

Scientists have discovered how a highly-endangered rainbow coloured bird has maintained distinct colours. The Gouldian Finch has maintained three distinct colour types for thousands of generations — finches with red heads, black heads and yellow heads — something that is extremely rare.

Now, scientists from the University of Sheffield, UK, in collaboration with the Cornell Lab of Ornithology, US, have discovered the underlying mechanism that allows this to happen.

The findings published in *Nature Communications* reveal that a gene, called follistatin, regulates melanin to produce either red or black-headed finches. However, the yellow-headed type, which make up less than one per cent of the Gouldian Finch population, is produced by a completely different mechanism that is not yet understood.

Lead author of the paper Kang-Wook Kim, from the University's department of animal and plant sciences said, "Most people have heard of natural selection, but survival of the fittest cannot explain the colour diversity we see in the Gouldian Finch. We demonstrate that there is another evolutionary process — called balancing selection — that has maintained the black or red head colour over thousands of generations."

The study shows that the red-headed finches are more dominant and preferred by female finches. Yet the reason the black-headed finches haven't disappeared is due to the fact there are disadvantages to the bird having a red head, such as higher levels of stress hormones and poorer reproductive outcomes.