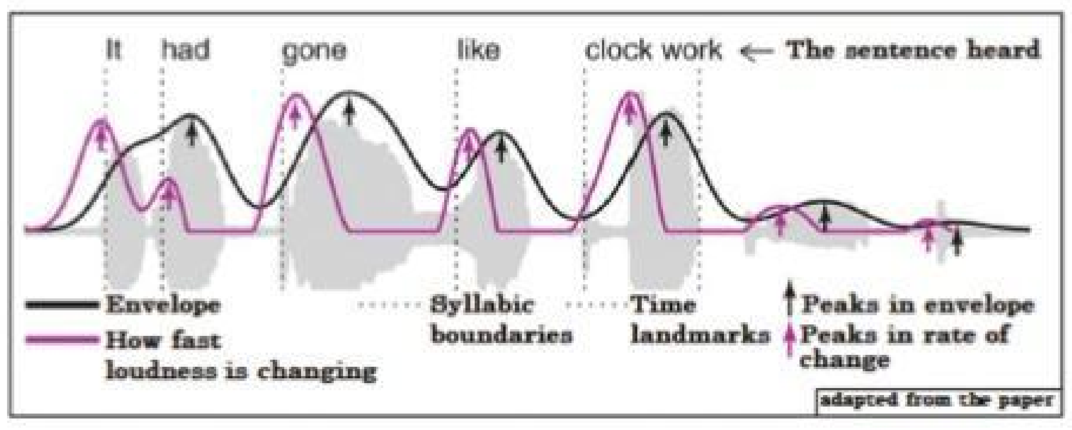
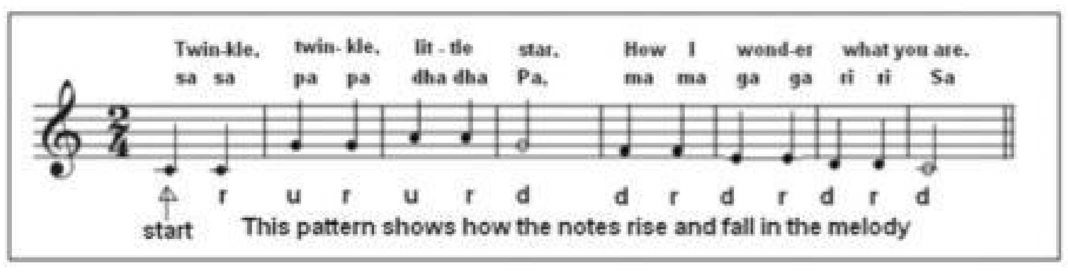
Sense and rhythm of the spoken word





Analyses of the ways in which the brain translates sounds have put forth some interesting findings

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How the brain translates sounds, in the form of speech, into meaning, is an enduring mystery. The fields of biology, medicine, mathematics, information technology and artificial intelligence are engaged in unravelling its complexity.

Yulia Oganian and Edward F Chang, from the department of neurological surgery in the University of California at Los Angeles describe in the journal, *Science Advances*, their work on how a part of the physical human brain responds to rising volume, or inflexions of loudness, to mark syllables heard in speech. The timing and extent of these changes in the level of sound underlies the coding of speech to meaning, the authors suggest.

The current understanding of the way organisms learn and make decisions is that neural pathways in the brain, or connections between brain cells, are strengthened when specific, but chance responses, to stimuli turn out to be pleasant or useful. These responses are then likely to be repeated, and finally they are learnt. This mechanism is simulated in AI, which enables computers to discover trends in data or develop strategies with greater efficiency, than they could by the usual methods of mathematical analyses.

For such analyses to be applied to speech and understanding, however, we need to understand how the barrage of electric signals, created by sound waves that strike the ears, are translated in the brain. And in this quest, analyses of the features of the sounds in speech, the sound of the vowels and consonants, patterns in the sounds and the sequences of words, similarities among languages, all become part of the study.

Human languages involve complex grammars and large vocabularies. There are hence a great many factors to consider and it is difficult to work out the basic codes into which the brain may split the sounds. Scientists have thus studied the simpler patterns, in the vocalisation of birds, which appear to communicate extensively with sound. Repetitive patterns, melodic forms, and even basic grammatical forms have been recognised in birdsong.

While studying dolphins, another species that uses sounds to communicate, it was found that there was a pattern in the variations of the pitch of the sounds, which was heard and remembered as the identity of individual dolphins. The study, in fact, made use of a modern, mathematical method that produces a concise coding of musical compositions of humans, and has helped computers search for instances of plagiarism or copy, over the Internet.

We know that melodies consist of patterns of rise and fall of pitch, along with variations in loudness and time. As there can be a huge number of combinations, the representation of a melody would involve a large collection of data. A simplified coding method is the Parson's Code, just the series of instances of the pitch rising, falling or staying unchanged. The picture shows the notes that appear in the song, "Twinkle, twinkle, little star." The notes are shown in the Indian notation and as western staff notation and the Parson's code, of the rising, falling or steady pitch is also shown, "u" as rise in pitch, "d" as fall and "r" as unchanged.

The code is certainly not a way to record or reproduce a tune, but the code turns out to be unique and a signature for most melodies. Using this code to mark the whistles of dolphins, scientists were able to identify the signals sent out to each one and they found that the whistles had meaning. One meaning the whistles contained was identity, but as they were unique, there may be more that they convey.

While these and other studies could help understand the nature of language, and meaning, once a pattern of words was there, one question is how the brain makes out the different words, given a continuous stream of sound signals. In computer coding of text, there letters are defined as combinations of "0" and "1", exactly eight characters long and there are specific codes to indicate spaces and full stops. In the genetic code in DNA, again, there are specific molecule combinations to mark the beginning and end of the coding for each protein. But how is the brain able to tell, from the stream of electrical impulses that it receives, that this is the end of one word and the beginning of the next?

The authors of the paper in *Science Advances* saw that there was a possibility of experiments with a collection of patients who were undergoing brain surgery at the Epilepsy Centre of the University. In preparation for surgery, the patients had arrays of electrodes attached to the brain surface, so that surgeons could map brain activity and assess what parts of brain tissue it would be necessary and safe to excise. As the electrodes were in place, the University of California team was able to record data of brain responses to sounds heard by patients who volunteered.

The trials were conducted with 11 patients where the electrodes were placed at areas associated with speech processing. The brain activity at those centres was then recorded while the volunteers listened to different speech recordings that were played to them. The result was a mass of data of the electrical activity of nerve cells in the brain in response to changing syllabic patterns and the varying loudness that we encounter in normal speech.

"The most salient acoustic features in speech are the modulations in its intensity, captured by the amplitude envelope," the authors say. The amplitude envelope is an outline of the variation in loudness of speech, as seen in a graphical representation in the picture.

The grey part of the picture is the sound energy, furthest from the baseline when the sound is louder. The black line is the outline or the envelope. But the rate of getting louder, the purple line, is not the highest at the point when the sound is the loudest (in fact, the loudness starts falling once the loudest point is reached). The fastest increase is earlier, when the sound is feeble but rising.

The envelope thus shows the timing of the emphasis in the speech, as at the beginning of the words in the sentence, "It had gone like clockwork." The words are separated and the places where the speaker places emphasis are marked. The paper says that when synthesised sound was used, it was seen that faster increase in loudness led to greater neuronal activity, rather than loudness itself.

The result indicates that the brain uses, and this may be a learnt behaviour, features in the stream of data that it receives to separate the words and places of stress, to differentiate between different sounds and hence, meaning. We are all familiar with how changing the point of stress in a sentence (like the place where a comma appears) can change the meaning of what is conveyed. In the Chinese language (and there may be others), the very meaning of words changes if the tone is rising, falling or both or flat!

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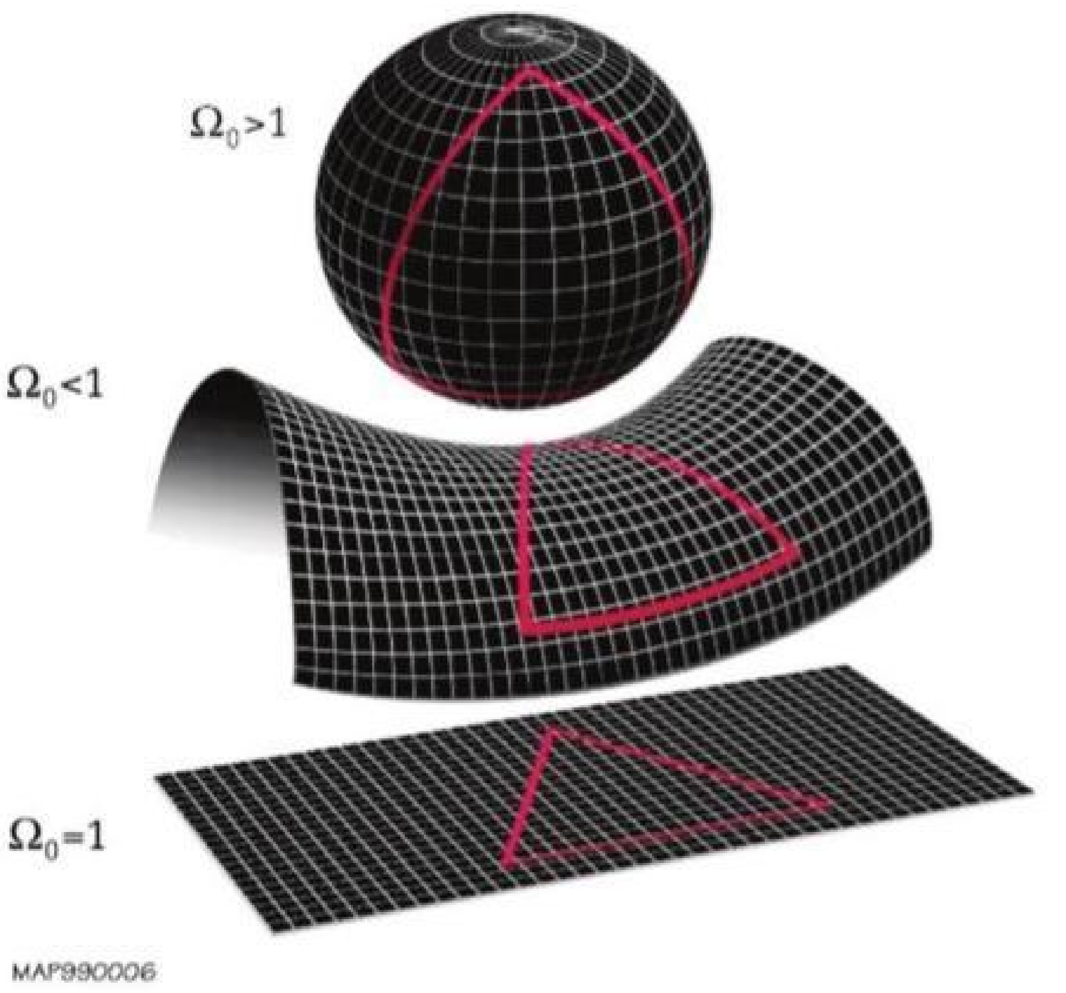
Pieces of the cosmic puzzle



ELEONORA DI VALENTINO

Could the shape of the universe be curved instead of flat?

No matter how elegant your theory is, experimental data will have the last word. Observations of the retrograde motion of the planets were fundamental to the Copernican revolution, in which the Sun replaced Earth at the centre of the solar system. And the unusual orbit of Mercury provided a spectacular confirmation of the theory of general relativity. In fact, our entire understanding of the universe is built on observed, unexpected anomalies.

Now our new paper, published in *Nature Astronomy*, has come to a conclusion that may unleash a crisis in cosmology — if confirmed. We show that the shape of the universe may actually be curved rather than flat, as previously thought — with a probability larger than 99 per cent. In a curved universe, no matter which direction you travel in, you will end up at the starting point — just like on a sphere, though the universe has four dimensions, including time.

The result was based on recent measurements of the Cosmic Microwave Background, the light left over from the Big Bang, collected by the Planck Satellite. According to Albert Einstein's theory of general relativity, mass warps space and time, around it. As a result, light rays take an apparent turn around a massive object rather than travelling in a straight line — an effect known as gravitational lensing.

There is much more such lensing in the Planck data than there should be, which means the universe could contain more dark matter — an invisible and unknown substance — than we think. In our study, we showed that a closed universe can provide a physical explanation to this effect, because it is able to host a lot more dark matter than a flat universe. Such a universe is perfectly compatible with general relativity.

Major headache

Not all cosmologists are convinced by a closed universe though — previous studies have suggested the cosmos is indeed flat. And if a spherical universe is a solution to the lensing anomaly, then we have to deal with several significant consequences. First of all, we have to revise a fundamental cornerstone of cosmology — the theory of cosmological inflation. Inflation describes the first instants after the Big Bang, predicting a period of exponential expansion for the primordial universe.

The theory was developed over the last 40 years to explain why distant parts of the universe look the same and have the same temperature, when they are too far apart to ever have been in contact. Inflation solves the problem because it means that far-flung regions of the universe would once have been connected. But the period of rapid expansion that hurled these regions apart is also thought to have also brought the universe to flatness with exquisite precision.

If the universe is closed, standard inflation is in trouble. And that means we lose our standard explanation for why the universe has the structure it has.

Once we assume that the universe is curved, the Planck data is essentially in disagreement with all other datasets. This all boils down to a real crisis for cosmology, as we say in our paper. For these reasons, cosmologists are cautious — and many of them prefer to attribute the results to a statistical fluke that will resolve when new data from future experiments are available.

Could we be wrong?

It is certainly possible that we turn out to be wrong. But there is one main reason, in our opinion, why this anomaly should not be merely discarded. In particle physics, a discovery should reach an accuracy of at least five "sigmas" to be accepted by the community. Here we are slightly above three sigmas, so we are clearly below this acceptance level. But while the standard model of particle physics is based on known and proven physics, the standard cosmological model is based on unknown physics.

At the moment, the physical evidence for the three pillars of cosmology — dark matter, dark energy (which causes the universe to expand at an accelerated rate) and inflation — comes solely from cosmology. Their existence can explain many astrophysical observations.

But they are not expected either in the standard model of particle physics that governs the universe on the smallest scales or in the theory of general relativity that operates on the large scales. Instead, these substances belong to the area of unknown physics. Nobody has ever seen either dark matter, dark energy or inflation — in the laboratory or elsewhere.

So while an anomaly in particle physics can be regarded as a hint that we may need to invent completely new physics, an anomaly in cosmology should be regarded as the only way we have to shed light on completely unknown physics.

Therefore, the most interesting result of our paper is not that the universe appears to be curved rather than flat, but the fact that it may force us to rearrange the pieces of the cosmic puzzle in a completely different way.

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PLUS POINTS

'Queer' behaviour

Homosexual and bisexual activity between animals has been well documented, with more than 1,500 species recorded in engaging in same-sex sexual behaviour. But despite the large body of evidence, evolutionary biologists have struggled to explain what has become known as the "Darwin Paradox" — why are these behaviours so common when they result in no opportunity for species to reproduce. And why, when animals have evolved over millennia, has same-sex sexual behaviour repeatedly evolved and persisted?

Researchers from the Yale School of Forestry and Environmental Studies suggest instead of examining the issue as a conundrum in need of a solution, the question ought to be reframed from "why do animals engage in same sex behaviour" to "why not?"

Writing in the journal *Nature Ecology & Evolution*, the authors suggest that these behaviours may actually have been part of the original, ancestral condition in animals and have persisted because they have few — if any — costs and perhaps some important benefits. "We argue that the frequently implicit assumption of (different-sex sexual behaviour) as ancestral has not been rigorously examined, and instead hypothesise an ancestral condition of indiscriminate sexual behaviours directed towards all sexes. By shifting the lens through, which we study animal sexual behaviour, we can more fruitfully examine the evolutionary history of diverse sexual strategies."

Lead author and doctoral candidate Julia Monk from the department, said, "We propose a shift in our thinking on the sexual behaviours of animals. We're excited to see how relaxing traditional constraints on evolutionary theory of these behaviours will allow for a more complete understanding of the complexity of animal sexual behaviours."

In the past, the researchers say research into species' sexual behaviours has rested on two assumptions. The first is that same-sex behaviour has high costs because individuals spend time and energy on activities offering no potential for reproductive success. And the other assumption has been that same-sex behaviours emerged independently in different animal species and evolutionary lineages.

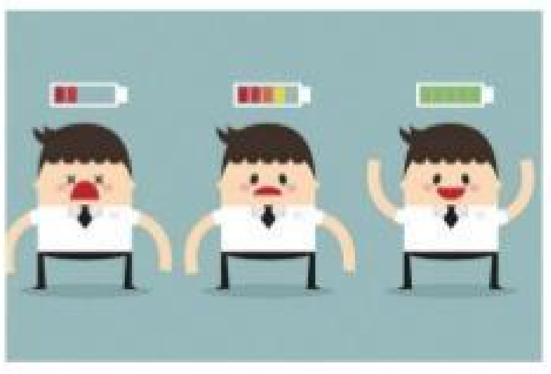
"If any trait other than homosexuality had been observed in such a diverse array of species it would be widely accepted as being part of our ancestral DNA rather than something that evolved later," said Monk. They argue a combination of same-sex sexual behaviours and different-sex sexual behaviours is an original condition for all sexually producing animals — and that these tendencies likely evolved in the earliest forms of sexual behaviour.

The authors suggest not only that same-sex behaviours are often "not costly", but can in fact be advantageous from a natural selection perspective because individuals are more likely to mate with more partners.

Many species aren't inherently monogamous but instead try to mate with more than one individual. In many species it can be difficult for individuals to even discern between different sexes.

The independent

Battery lifetime



Nine out of 10 people have "low battery anxiety", a condition that induces panic when one's phone battery drops to 20 per cent or lower, according to a recent study by technology company, LG.

As it turns out, there are ways you can prevent your phone battery from giving up at the worst moments. The trick is to keep your battery charged at between 25 and 85 per cent, as advised by Liz Hamilton, the director of people and customers at Mobile Klinik, a mobile phone repair business.

"The life of a lithium-ion battery is generally 500 cycles, about a year and a half. A battery cycle is measured by one full charge of 0 to 100. So, the more full cycles your phone goes through, the sooner you have to change it," she said.

The jakarta post/ann