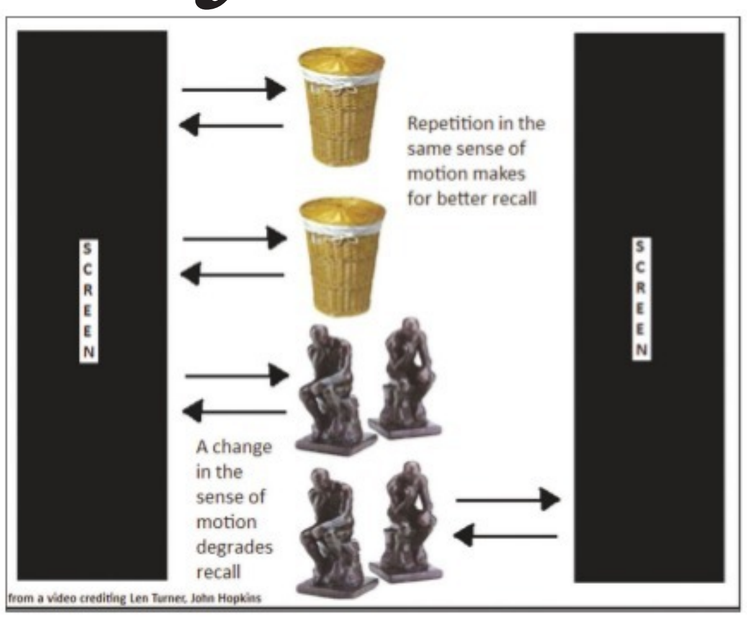
# When machines learn from us

SEEING IS BELIEVING BUT IT LOOKS LIKE WE NEED TO BELIEVE IF WE ARE TO REMEMBER WHAT WE SAW, WRITES **S ANANTHANARAYANAN**



from a video crediting Len Turner, John Hopkins

Being able to recognise things, or faces, which we have seen before, is both to remember what it looked like and to know it is the same thing even if it were oriented differently the second time we see it. Automating the act of making out the object, or pattern recognition by machines is hard enough. To be able to make it out even when it looks different, like humans can, is a puzzle that the computer world is yet to crack.

Understanding how the human eyes and brain can remember and recognise a great variety of objects would help computer scientists find ways to improve the performance of machines. While there has been some progress towards this understanding, Mark W Schurgin and Jonathan I Flombaum, department of psychological and brain sciences, Johns Hopkins University, in their paper in the Journal of Experimental Psychology, bring out yet another aspect of the act of recognition of things briefly seen, by humans. With the help of a remarkably simple experiment, they show that people who see a thing briefly on two closely separated occasions are more likely to remember if they believe it was the same thing that they saw the second time too.

One feature of remembering objects or people is that we remember better if we see them in motion. When an object moves across the field of vision, it presents more than one view of its three-dimensional self and the collection of images we receive creates in our brain a more rounded picture. We are then better equipped to recognise the object when we see it again, even from a different angle or position that we have not encountered. This is equally true when we see people, of course, and when people move, we also see a unique and personal method of movement, which can identify the person even if seen the next time around in poor lighting!

Seeing a moving object is again not a passive act but one where we move our eyes, head and body. The movement of the eyes is to bring an object that we see on the periphery, to the centre of our field of view. And these movements, along with the movement of the object itself, lead to muscular action being associated with the images, several of which, from different angles, get imprinted in our brain. One known part of the process of creating a memory, the John Hopkins paper says, is a "temporal association rule". This is to say that a short encounter with an object, maybe a few seconds, or less, can be considered as creating a series of independent images, one changing into the other, of the same object. The way the images change over the short exposure gives the brain bases to imagine what changes in the object to expect in a subsequent exposure, to help recognition.

The experiment of the John Hopkins duo examined how the brain selects images of an object in motion, which were formed in quick succession, to store as changing images of a specific object. While the association with the movements of the eyes as an object was seen in motion, would help identify all images as of the same object, there is an understanding that the brain uses its past encounters, or notions, known as "core knowledge" about the world to make out which of the images that it sees are of the same object. One part of this knowledge is the way things move, which helps us identify the correct images of objects in motion. And the John Hopkins experiment set out to test this idea.

The experiment consisted of flashing a pair of images of an object, one after the other, in front of an observer. How well the observer recalled the object was then tested, to see if she could tell the difference between an object she had been shown and another that looked a lot like it. The effect of the experience of the observer, on how well she stored the two images of each object that she was shown, was tested through a variation in the way the two images of each object were shown. The way the objects were briefly displayed was by showing them to be darting out from behind a screen and then back to be hidden again — doing this twice. In half the cases, however, the second appearance of the object was not from behind the same screen, but from behind another screen on the other side of the display.

The result of the trials was that objects shown both times from the same side of the display were remembered some 20 per cent better. And the conclusion drawn is that both the images were stored as relevant images, to help recall, when the brain could expect that the object emerging from behind the same screen was the same object as had been seen before. When the object emerged from different sides, however, they were more likely to be some different objects and the two images were not stored together. The object was then less effectively recalled. "Your brain has certain automatic rules for how it expects things in the world to behave. It turns out that these rules affect your memory for what you see," says Schurgin, graduate student at the University.

The image that physically appears before both the eye and a camera screen is only a collection of illumination values of arrays of nerve cells, pixels, or light sensing devices. It is the brain, or the pattern recognising software, that needs to make sense of the raw data. While pixel by pixel comparison against a recorded template could work only if the image shown is the same as what is in memory, machine systems employ different approaches to extract the essential features from the original, to look for in new images, which may be not the same but similar. And then, computers are programmed for "machine learning", or to improve the process that they use for recognition, as and when they encounter more instances of images, and the feedback of how well they identified them.

Image processing by machines is growing in importance, with the development of driverless cars, automatic surveillance systems, robots to deal with production lines and for security of banking transactions. The present work by Schurgin and Flombaum could help create machine learning systems that derive value from images in motion and to select, based on past encounters, the images that need to be stored and from which it would be useful to learn.

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# DO YOU WISH TO ERASE THEM?

Scientists have demonstrated "proof of principle" that traumatic memories can be erased from the brain — as seen in the science fiction film, Eternal Sunshine of the Spotless Mind.

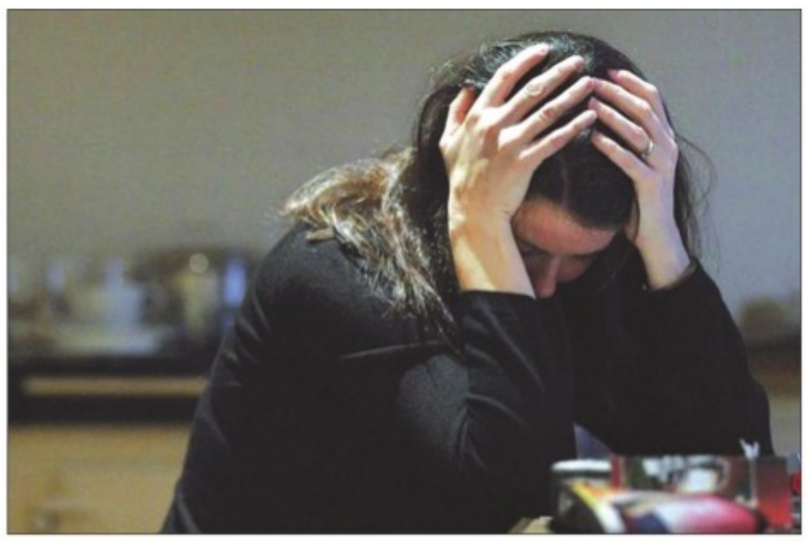
Studies in mice demonstrated that fearful memories prompted by a sound associated with an electric shock could be turned off and on. The researchers said, however, that attempting to experiment on humans was full of ethical problems and some way off. But their studies suggest it will be possible at some point in the future, for example, to treat people suffering from post-traumatic stress disorder or drug addiction.

Speaking recently at the annual meeting of the American Association for the Advancement of Science in Boston, Sheena Josselyn said that they had been able to discover the specific brain cells where a particular memory was stored. "So we can target where in the brain a memory has gone," she said. "We can then decrease the activity in these cells ... And it is as if we erase the memory." After this was done, the mice were unperturbed when they heard the sound they had previously learned to associate with the shock.

Increasing the cells' activity restored the memory of the shock — enough to be unpleasant but not to cause lasting harm — to the mice. "We can turn memory on and turn memory off," Josselyn said, "It really does give us proof of principle. If there's a memory problem, we don't have to target the entire body or the entire brain."

Josselyn, of Toronto University, said that it was possible that in the future scientists could develop "a heat-seeking missile or a heat-seeking drug that would somehow operate on just the cells important for this memory". "We can erase a fearful memory in mice, suggesting in people there might be a way of targeting just those cells that are important in just this traumatic memory and perhaps getting rid of it," she said. "The spotless mind," interjected Professor Howard Eichenbaum, director of the Centre for Memory and Brain at Michigan University, who was taking part in the same briefing to the press at the meeting.

In Eternal Sunshine of the Spotless Mind, an estranged couple erases memories of each other after breaking up, but things do not go quite to plan. Eichenbaum cautioned that there were a limited



SCIENTISTS SAY THAT MEMORIES CAN BE SWITCHED ON AND OFF BUT EXPERIMENTS ON HUMANS MAY NOT BE POSSIBLE ANY TIME SOON DUE TO ETHICAL CONSIDERATIONS. **IAN JOHNSTON** DELVES DEEPER

number of brain cells involved in such memories and killing off one memory might damage others. But he added, "If this memory was particularly severe and was destroying your life, then it might be a reasonable compromise."

Asked about the ethical considerations, Josselyn said that being able to target the potential treatment was a key issue, adding that she did not see a future in which brain cells would be killed off to remove memories. "The ethics are a really important question. I think we are the sum total of our memories," she said, "We all learn from our mistakes. If we erase the memory of our mistakes, what is to keep us from repeating them?"

But she added, "For something that really interferes with your everyday life, I think a treatment that targets just those cells could be appropriate." In addition to removing fearful memories, the researchers have been able to get rid of memories associated with taking cocaine among the mice, suggesting this could lead to new ways of treating drug addicts.

Memories are stored in what is known as an engram, which consists of brain cells that fire in a particular pattern. When something happens, the brain cells, or neurons, compete against each other to

store the memory. Josselyn said, "We showed that if two related events occur in a small time window — six hours — then the same neurons win the competition for allocation to both engrams.

"This links the two related memories. If, on the other hand, two events occur more than six hours apart, non-overlapping populations of neurons are recruited and the memories are kept separate.

"Our results suggest that this neuronal competition during memory formation is a mechanism that links or disambiguates related emotional memories."

THE INDEPENDENT

# The source of lipids

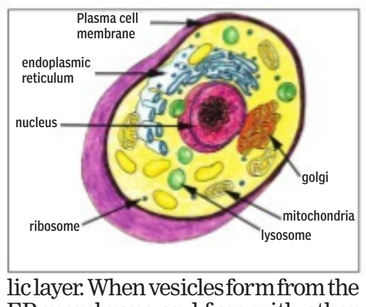
THE ENDOPLASMIC RETICULUM PLAYS A CENTRAL ROLE IN THE BIOSYNTHESIS OF MEMBRANES, WRITES **TAPAN KUMAR MAITRA**

The biosynthesis of lipids and their fates within eukaryotic cells reveal that the endoplasmic reticulum is the primary source of membrane lipids including phospholipids and cholesterol. Indeed, most of the enzymes required for the biosynthesis of the various membrane phospholipids are found nowhere else in the cell.

There are, however, important exceptions. For example, while mitochondria import from the ER all of the phosphatidylcholine, phosphatidyl inositol, and phosphatidylserine found in their exterior and interior membranes, they acquire phosphatidylethanolamine indirectly by decarboxylating imported phosphatidylserine. Other significant exceptions are the biosynthesis of cholesterol and dolichol by peroxisomal enzymes and the synthesis of chloroplast-specific lipids in the chloroplast.

Biosynthesis of phospholipid molecules is restricted to one monolayer of the ER membrane. Specifically, the active sites of the enzymes involved are exposed to the cytosol, and newly synthesised lipids are incorporated into the monolayer of the membrane that faces the cytosol. Cellular membranes, of course, are phospholipid bilayers, with phospholipids distributed to both sides. Thus, there must be a mechanism for transferring phospholipids from one layer of the membrane to the other. Because it is thermodynamically unfavourable for phospholipids to spontaneously flip at a significant rate from one side of a bi-layer to the other, transfer depends on phospholipid translocators, or flippases, which catalyse the translocation of phospholipids through ER membranes.

Phospholipid translocators, like other enzymes, are quite specific and affect only the rate of a process. As a result, the precise phospholipid molecules transferred across a membrane depend on the complement of translocators available. Therefore, this translocator specificity contributes to the membrane asymmetry. For example, the ER membrane contains a translocator for phosphatidylcholine, but not for phosphatidylethanolamine, phosphatidylinositol, or phosphatidylserine. Consequently, phosphatidylcholine is found in both the cytosolic and lumenal layers of the ER membrane whereas the latter three phospholipids are confined to the cytosolic layer. When vesicles form from the ER membrane and fuse with other organelles of the endo-membrane system, the distinct compositions of the cytosolic and lumenal layers established in the ER are transferred to other cellular membranes.




Movement of phospholipids from the ER to a mitochondrion or chloroplast poses a unique problem. Unlike organelles of the endo-membrane system, mitochondria and chloroplasts do not grow by fusion with ER-derived vesicles. Instead, phospholipid exchange proteins (or phospholipid transfer proteins) found in the cytosol convey phospholipid molecules from the ER membrane to the outer mitochondrial and chloroplast membranes. Each exchange protein recognises a specific kind of phospholipid, removes it from one membrane, and carries it through the cytosol to another membrane. Such transfer proteins also contribute to the movement of phospholipids from the ER to other cellular membranes, including the plasma membrane.

Although the ER is the source of most membrane lipids, the compositions of other cellular membranes vary significantly from the composition of the ER membrane. For example, a striking feature of the plasma membrane of hepatocytes is the relatively low amount of phosphoglycerides and high amounts of cholesterol, sphingomyelin, and glycolipids an increasing gradient of cholesterol content from the ER through the compartments of the endo-membrane system to the plasma membrane. This correlates with an increasing gradient of membrane thickness. ER membranes are about five nm thick, whereas plasma membranes are about eight nm thick.

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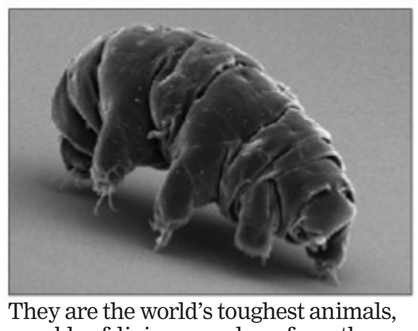
## PLUS POINTS

### Indestructible animals



They are the world's toughest animals, capable of living anywhere from the bottom of the ocean to 5,500 metres up a Himalayan mountain. They can be boiled at temperatures of up to 150 degrees Celsius or frozen to near absolute zero, but still tardigrades — tiny, Muppet-like creatures also known as water bears or moss piglets just will not die. They have even been found on the outside of the International Space Station, where the lack of pressure would kill a human in minutes at most. The tardigrades found it so pleasant, they decided to settle down, have sex and produce offspring. Now researchers have discovered how they pull off one of their most extraordinary survival techniques.

Dr Thomas Boothby, of North Carolina University, who led the study, said, "The big takeaway from our study is that tardigrades have evolved unique genes that allow them to survive drying out. In addition, the proteins that these genes encode can be used to protect other biological material like bacteria, yeast, and certain enzymes from desiccation." These proteins have been named TDPs or tardigrade-specific intrinsically disordered proteins in honour of the 1mm-long creatures who evolved to have them.

Previously it had been thought that a type of sugar called trehelose, which is found in other organisms including brine shrimp, was the secret behind the tardigrade's Lazarus-like ability to return from the dead after being dried out for up to 10 years. Following the discovery, reported in the journal Molecular Cell, the scientist put the genes into yeast and bacteria, which then gained the same properties as the tardigrades.

Dr Boothby said TDPs could be used to protect crops from drought and to preserve medicines without using a refrigerator. "Being able to stabilise sensitive pharmaceuticals in a dry state is very important to me personally," he said. "I grew up in Africa, where lack of refrigeration in remote areas is a huge problem. These real-world applications are one of the things that led me to study tardigrades."

IAN JOHNSTON/ THE INDEPENDENT

### Plastic cups in whale

Singapore's murky waters are an unexpected treasure trove of marine life, and the greatest proof of that now hangs at the Lee Kong Chian Natural History Museum. The skeleton of a 10.6m-long sperm whale takes pride of place there, and it is little wonder why. It is the first sperm whale to be documented in the Republic.

Jubi Lee, as the whale is affectionately known, was found dead and floating off Jurong Island two years ago, when Singapore was having its golden jubilee celebrations. Observations showed it had suffered a deep cut that may have been caused by a collision with a ship.

But the whale still had a story to tell. Researchers have documented findings based on their study of the sea mammal, to raise awareness of the importance of marine conservation. The story of how the giant sea creature was treated is being told in a new book launched recently by the museum.

"The 50th year of Independence, 2015, was marked by the return of the Singapore whale," wrote Professor Tommy Koh, chairman of the museum's advisory board, in the foreword. "Unlike the whale of 1892, this whale was actually found in Singapore's territorial waters."

He was referring to a 12.8m Indian fin whale that had been found in Malaysia. It was hung at the old National Museum in Stamford Road from 1907 to 1974 before it was given to Malaysia.

The 155-page book, titled A Whale Out Of Water: The Salvage Of Singapore's Sperm Whale, details how the whale was found, scientific discoveries arising from the carcass, and how museum staff worked round the clock to preserve its skeleton. One important discovery was what researchers found in the gut of the whale. Other than the remains of squids — a major part of its diet, they also found plastic cups.

"Mixed emotions were felt as we discovered both the astounding appetite of a whale and the devastation humans are causing to nature," wrote the authors, museum staff Iffah Iesa, 25, and Kate Pocklington, 30. "Among the thousands of indigestible squid beaks and eye lenses, was a collection of plastic wrappers and cups." Visitors can view footage of the whale's dissection at the museum's new Out Of The Water exhibition.

THE STRAITS TIMES/ ANN