The lexicon of emotions

Is there a common thread that connects different symbols underlying a state of mind?

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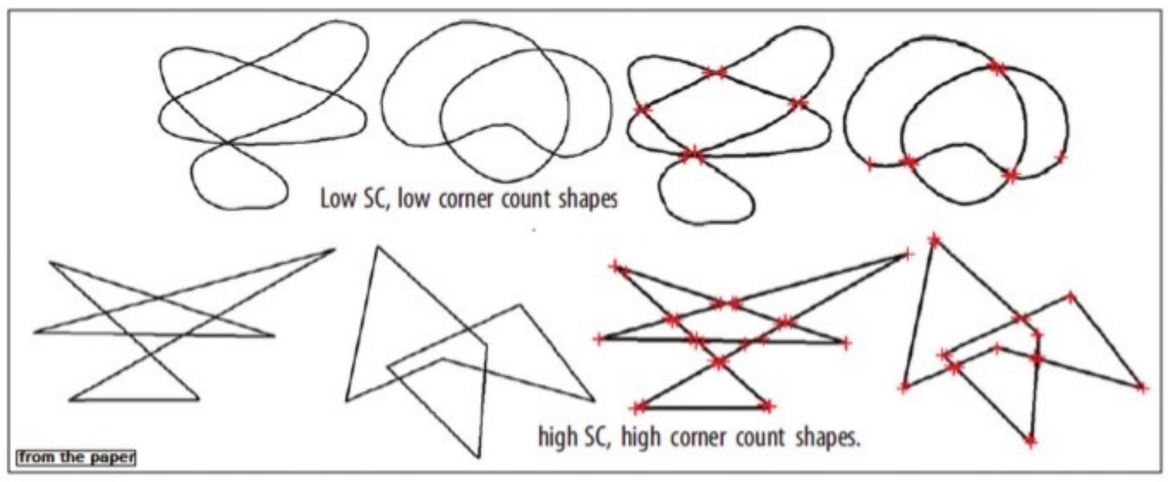
Raised voices and flailing arms usually accompany fury. Graceful movements and melodious tones suggest peace and tranquility. Are there parallels in vocal and visual symbols, colours or forms of expression? Are those symbols universal? Or are they culture specific?

Beau Sievers, Caitlyn Lee William Haslett and Thalia Wheatley, from Harvard University and Dartmouth College and the Geisel School of Medicine, Hanover, New Hampshire, US subject such questions to scientific analysis and present their findings in the journal, *Proceedings of the Royal Society*, published from London. The authors find that emotional arousal is conveyed and perceived with the help of a stimulus feature that is the same with the different senses, which leads to symbols that are used being shared between cultures and even, species.

The authors refer to earlier work that suggests that music and movement, as in dance or a military march, share features, which tally with the kind of music that is associated with kinds of movement. There is also evidence, they say, that basic, low-level physical features of shape, sound, colour and motion are shared when emotions are expressed or interpreted. The authors were hence motivated to enquire into the mechanism that brings this about.

The authors developed an index, or unit of measurement, that could characterise a sound, or a vocal signal, and they extended the unit to visual or other forms. In the case of vocal signals, any complex sound can be considered as many simple tones sounding together. In the pure tones of the flute or the violin, for instance, the vibration of the air is at the same rate as the named pitch of the tone. In complex tones, as of a trumpet, however, the character comes from the mixing of overtones of the basic



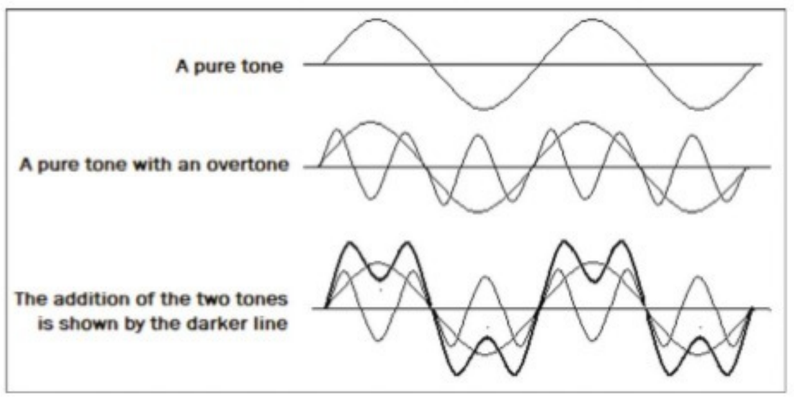
tone, as shown in the figure. We can see that the shape of the outline, when the two tones are put together, is bumpier than with pure tones.

We can also imagine that the energy in a complex sound is distributed over the frequencies that it consists of. While the energy at some frequencies may be larger than at others, a central frequency that could be considered to account for all the energy would be somewhere near the most energetic frequencies. The authors work out this frequency, as the "spectral centroid", a kind of "centre of gravity", but in the terms of pitch.

The authors also referred to studies that have related shapes and sounds, with sharp sounds or soft sounds being related to spiky shapes or rounded shapes, and devised a measure of the "spectral centroid" of shapes. As shown in the picture (*above*), rounded shapes have low SC, while shapes with many corners have high SC.

The experiment was then to test the proposition that high SC sounds and high SC shapes were related to high arousal emotions, like being angry or excited, while low SC sounds and shapes were related to low arousal emotions, like being sad or peaceful.

The first trial was to see whether the SC of a stimulus was correlated with emotional arousal. Pairs of shapes were created, with the general outline matching, but with low or high SC. A set of sounds was also created, using non-phonetic pairs, 1.5 seconds long, with low or high SC. The sound to match the spiky shape



consisted of four 54-millisecond bursts, sounded out of beat. The sound to match the smooth shape was a low pitch, pure tone, varying in loudness with a rhythm that matched the bursts in the other sound.

In the trial, participants, on seeing a shape, had to choose emotions, either "angry" or "sad". Other participants had to see shapes and choose between "peaceful" or "excited". And with sounds, again, a group of participants made choices, on hearing sounds of high or low SC. "Across all matching tasks, participants associated high mean SC sounds (noise burst) and shapes (spiky) with high-arousal emotions (angry, excited), and low mean SC sounds (sine wave) and shapes (rounded) with low-arousal emotions (sad, peaceful)," the paper says.

The second trial was to see how people might choose shapes to express emotional arousal. Participants were first shown a shape, which they had to classify as "angry" or "sad". Next, they had to draw a shape that stood for the emotion they did not choose. And then answer questions — what was difference between the shapes? And why did you draw what you did? A second phase of the trial was carried out in the same way but without a prompting image. The participants, of course, were chosen so that they had no idea what the trial was about.

In the first part of the trail, angry shapes were found to have a mean of 23.3 corners while sad shapes had 6.6. In the second part, where there were both negative and positive emotions, angry shapes had 24.2 corners, sad shapes had 8.8, excited shapes had 17.1 corners and peaceful shapes had 6.8.

The third trial was to test the hypothesis that shapes and sounds shared a relationship with emotional arousal. This was done by creating a large and varied sample of shapes and sounds and getting a theoretical model to predict what the response of participants may be. The result was that the most elaborate model, which evaluated SC, counted corners and all other features, got it right 78 per cent of the time. With only SC and corners considered, the result was 77 per cent, but other models seemed to flounder. This shows that SC is a reliable indicator of what emotion the symbol would evoke, the paper says.

The next trial was to see if SC could predict judgements of extracts from databases of professional actors portraying emotions and reading emotionally neutral sentences. With SC for the vocal part and a suitable SC derived for movements, it was found that SC could correctly classify "angry" and "sad" expressions 86 per cent and 90 per cent of the time. The last trial was again drawn from the data bases, but portraying a range of emotional arousal categories. While the samples were in German, the participants selected knew no German. There again, SC was found to be a reliable predictor of the emotional arousal a sound or form would evoke.

A valid question that can be raised is that the code of SC, by which sounds and shapes are found to convey emotion, could be learnt by all of us during our early years. The trials may hence not really prove that the code is universal. As an answer to this, the paper cites a report of similar trials, which were carried out in L'ak, a remote Kreung village in northeastern Cambodia. What is special about this village is its geographical and cultural isolation. The results of the study at L'ak, which were replicated in the US, showed that common features relating different modes, like sound or shape, are independent of the cultural setting. Going further, the paper cites studies that show that humans are able to recognise emotional arousal from the vocalisation of animals.

While the paper notes that "understanding how the brain extracts low-level, cross-modal features to determine meaning" would advance our knowledge of communication, we can rest easy in the thought that there is still no algorithm that can create sounds or shapes to arouse emotions like a Mozart or Van Gogh!

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Light at the end of the tunnel

India-born biomedical researcher Rajiv Mohan, working in the US's University of Missouri, is pursuing a singular mission — giving sight to the sightless

Growing up in India, Professor Rajiv Mohan learned to treasure the gift of sight as he watched relatives struggle to see. Three uncles, three aunts and a grandfather suffered with eye problems, including blindness. "They have double vision. They have myopia, hyperopia and things like that. It is all connected with the cornea. It is all preventable and treatable," Mohan said, "I wanted to do something where I could make a difference."

So he became a biomedical researcher, moved to the United States and pursued a singular, global mission — to help bring sight to the sightless. As a University of Missouri professor and researcher, Mohan has developed a way to genetically alter a pathway that limits the amount of light that enters the eye — in effect bringing light to the darkness.

Mohan seeks to treat a disability called "corneal fibrosis" or "corneal vascularisation," variations of a common eye problem. According to a review article published in the journal Eye and Vision, corneal disease is the third most frequent cause of blindness in the world. An estimated 1.4 million people develop corneal neo-vascularisation per year, and 12 per cent of them go blind.

Vision problems are a big issue in developing countries, including India. "Prevalence of corneal blindness in India ranges between 1.9 to 4.3 per cent as reported in various studies," wrote Bhavana Sharma, one of Mohan's collaborators in India.

But though the research shows promise, it's still in the early stages and must clear several regulatory hurdles. So a treatment may be years away.

A love of the laboratory

Mohan was born, raised and educated in India. "When I was doing my Master's, I saw people going into the lab," he said. "It was always very intriguing to me, to watch them do what they are doing, late into the night, all the time. I asked them what they did, and that made me really interested in the area." He got a scholarship to pursue a doctoral degree.

An organic chemist by training, Mohan transitioned to molecular biology after receiving a post-doctoral research opportunity in the US. After that, he received academic appointments at some of the leading eye


Rajiv Mohan in his University of Missouri research centre

research institutes in the country, including the University of Washington and Case Western Reserve University. He joined the University of Missouri faculty a few years ago after receiving an offer from an administrator who wanted to enhance ophthalmology research.

Now, he works in a lab similar to the ones that fascinated him as a young man. His lab is in the basement of the Veterans Affairs Medical Center in Columbia, Missouri, down a maze of hallways illuminated by fluorescent light. Along the aisles of the lab are long benches covered with research equipment and instruments. From early morning to late evening, Mohan and his research colleagues mix liquids and push buttons on the equipment. Their goal is to understand corneal damage and find the best way to treat it.

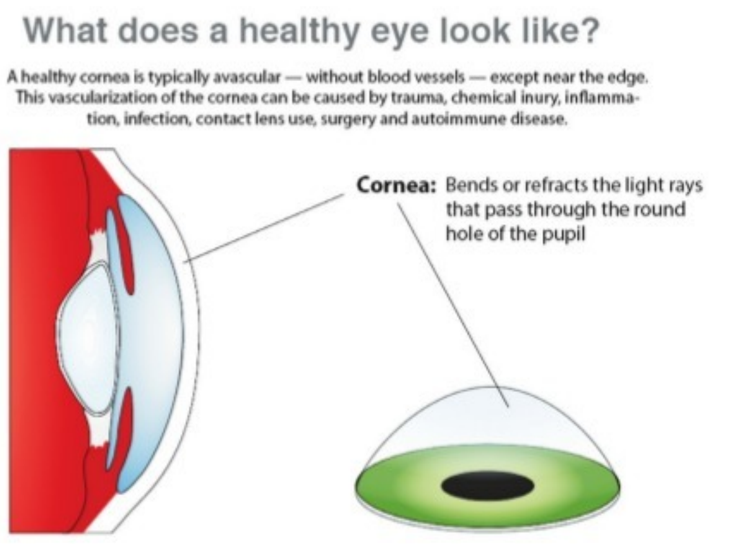
This damage interrupts the complicated process of sight. Vision involves light, with eyes controlling and directing light to a single point located at the back of the organ before transferring information to the brain. "When (light) comes and enters the eye, it is first bent by the cornea shape," said John Jarstad, an associate professor of clinical ophthalmology. "It passes through the cornea, through the pupil, which is made up of the iris muscle. It goes through the pupil, and then it is also bent again by the lens of the eye." From there, signals are sent to the brain via the optic nerve, which processes the information for vision.

The cornea can be damaged for several reasons, through physical damage or by chemical means, causing problems with vision. Issues can also arise as the body tries to repair the damage. "A lot of times it is the healing, and the scar tissue that comes from healing, that really affects the vision the most," Jarstad said.

Once the cornea is damaged, scar tissue forms. That scarring can hinder the light that passes through the cornea, which limits vision. "In general, you would see probably more than one million people who require some sort of treatment of the scarring related to vision loss in India," said Arkasubhra Ghosh, one of Mohan's collaborators in the US.

Treatment shows promise, borders on 'science fiction'

Mohan's treatment is based on genetics. "Gene therapy is a type of treatment where we introduce a new gene or over-express a gene. In other words, we take a gene that is normally present and make more of it, or potentially replace a defective gene, something that makes a broken product that doesn't work properly and replace it with a new, functional protein," said Jason Rodier, an assistant



professor of clinical ophthalmology.

The foundation for any protein production process within living organisms is the DNA, which is essentially a string of chemical designations providing an instruction manual for making different parts of an organism. Mohan's treatment would rewrite the instruction manual to limit the scar tissue hindering the amount of light passing through the cornea. "It borders on science fiction," Rodier said.

The treatment is showing promise in a preclinical setting, which involves using rabbits to mimic the disease and apply the treatment." We put genes in the healthy cells, which is near those (injured) cells," Mohan said, "These cells start producing extra amount of proteins, which kills those cells..."

Gene therapy takes advantage of economies of scale. A single treatment can be used multiple times, meaning it can potentially help many people — whereas transplants require procuring tissues from deceased donors.

Mohan's research is now moving into human trials. He's soliciting help of colleagues in India, asking them to recruit patients and collect tissue samples. "Our contribution to the project is to bring in the knowledge of how the molecular pathways work in human beings, the clinical knowledge of how the scarring happens and how the disease progresses," Ghosh said.

When that's done, they will begin developing treatments for patients — with the goal of eventually making them commercially available. "I am hopeful that in the next four years, both phases will be successful," Ghosh said.

Researchers then face another set of hurdles — rigorous clinical trials to ensure the treatment is safe. Those can take a dozen years. Given this timetable, the treatment may not be available for two decades.

Gary Wunder, a member of the National Federation of the Blind, said he's glad the research is under way, but people living with blindness shouldn't put their lives on hold.

"I think that we believe that anything that will help people get and keep their vision is a good idea," Wunder said. "But too many people wait for these cures instead of taking advantage of the limited lifespan that they have to still be happy and productive, and not feel sorry for themselves."

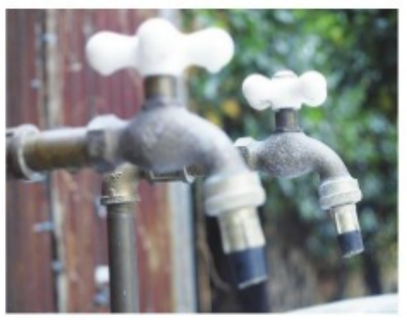
Gene therapy and Indian healthcare infrastructure

If the gene therapy method becomes widely available, then does India have the infrastructure to implement this? "Yes, there are places in India which do have the infrastructure," says eye specialist Dr Anup Goswami, "However, cornea grafting is an old and reliable method. It has a good success rate. But Indian society has certain social and religious aspects, which lead to many people not wanting to donate their eyes upon death. Given the number of corneas that are needed, we usually have a huge shortage in donations."

With inputs from Ralph Chapoco, Sean Na and Karina Zaiets from the US and Godhuly Bose from India

PLUS POINTS

Water in everything



Researchers at the Indian Institute of Technology, Hyderabad, have undertaken a study of the "water footprint" of Hyderabad Metro Development Authority region. Such assessment studies are vital as development of strategies for sustainable water preservation hinges on understanding the pattern of water usage.

It has found that while agriculture accounts for nearly 70 per cent consumption of "physical" water, in what is known as the "green water footprint", urban areas consumed nearly 20 times more "virtual" water through their various consumption items than physical water, contributing to the "red footprint." Such hidden consumption patterns put enormous pressure on the already taxed water resources, which necessitates a proactive plan for conservation activities. Given the water insecurity and trans-boundary water conflicts that threaten global peace, such studies would help in framing strategies and laws towards fair distribution of water.

The study was led by Professor Dornadula Chandrasekharam, visiting professor, department of civil engineering, IIT-Hyderabad, and his research scholar, Dagani Koteswar Rao. It has been published in the peer-reviewed international journal, *Sustainable Cities and Society*. Explaining the various ways in which water is consumed, Chandrasekharam said, "The obvious image of water consumption that comes to mind is the active or direct water ingestion by human beings, but the water footprint of humankind extends far beyond. Every single item that we use in our daily life has used water at some part of its lifecycle. Water that is hidden in non-obvious human commodity is called 'virtual' water and the 'water footprint' measures the amount of water that has gone into the goods and services that we use."

The assessment of water footprint embedded in products was done in four broad categories — food consumption, fuels based on fossil energy, electric power and direct water (municipal drinking water). The maximum virtual water consumption was seen to come from the food industry (70 per cent), followed by the electric power sector (25 per cent). Surprisingly, the fossil fuel sector used only one per cent of the total water consumed by this city.

"The published work did not consider the industrial and commercial water usage pattern", said Chandrasekharam and added that further studies are ongoing to assess those areas as well.

Making it snow

Vast snow cannons could be used to repair the West Antarctic ice sheet and prevent catastrophic sea level rise, leading climate scientists have suggested.

Seawater could be turned into ice and then pumped onto the glacier, generating trillions of tonnes of additional snowfall, which researchers believe could — in theory — stave off the complete collapse of the West Antarctic ice sheet. If this collapse were to happen, global sea levels could rise by more than three metres, submerging low-lying global metropolises such as London, New York and Shanghai.

The project would need "unprecedented" feats of engineering and could pose a substantial environmental hazard to one of the world's last pristine regions. However, scientists are divided as to whether such extreme measures would even work.

"The apparent absurdity of the endeavour to let it snow in Antarctica to stop an ice instability reflects the breathtaking dimension of the sea-level problem," said Anders Levermann, from the Potsdam Institute for Climate Impact Research and one of the authors of the study published in the journal *Science Advances*.

In this latest study, researchers looked at computer simulations to project the dynamic ice loss in the future around Pine Island and Thwaites Glaciers in West Antarctica. They were able to confirm previous findings, which had found even strong reduction of greenhouse gases may not prevent the collapse of the West Antarctic Ice Sheet, according to the paper published in Science Advances.

The independent