

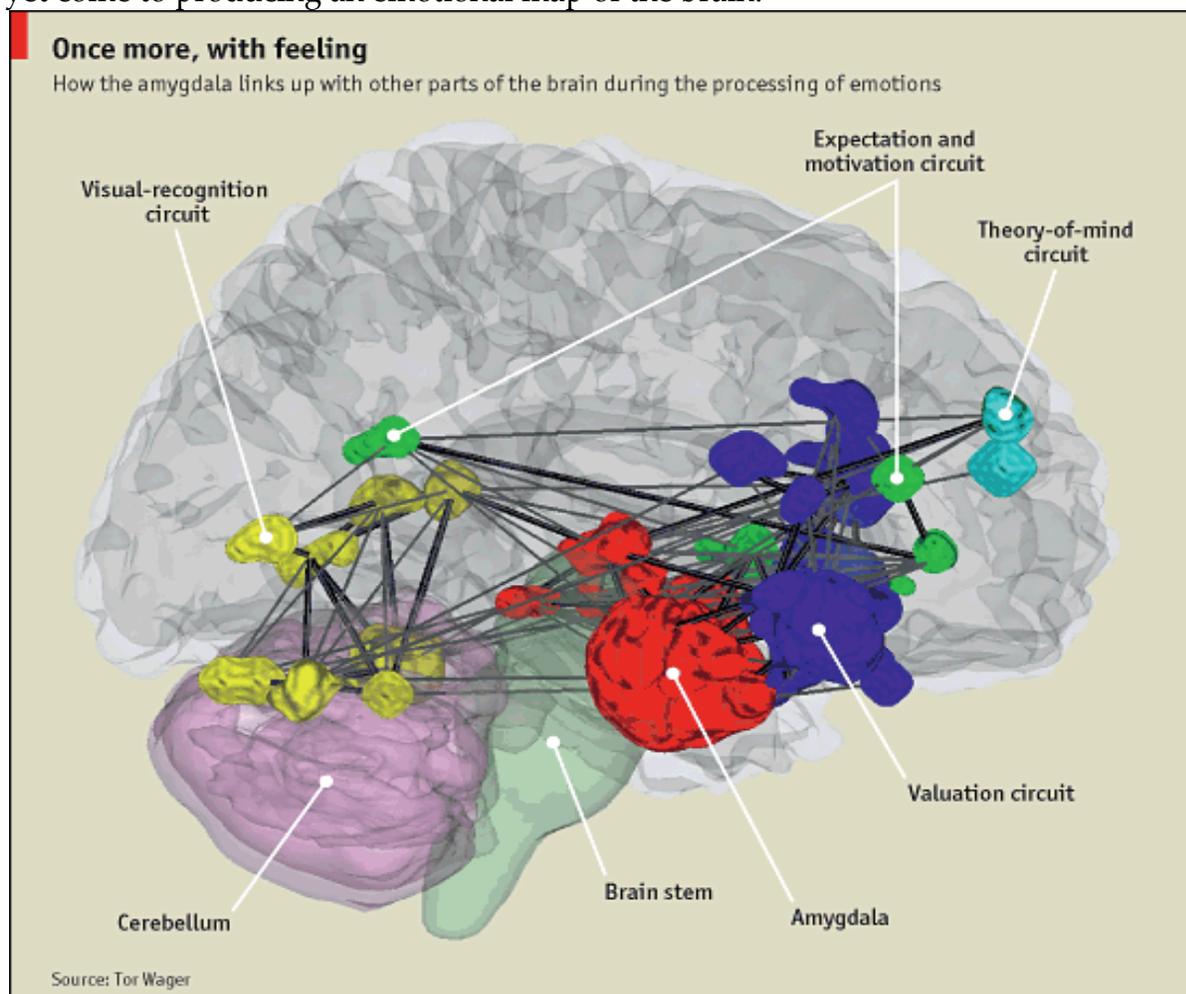
Captain Kirk's revenge

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Emotion is essential to human survival

ONE neuroscientist who could not be accused of dealing in small samples is Tor Wager, of Columbia University in New York. Dr Wager studies emotions—or, rather, he studies other people's studies of emotion. He has gathered together every fMRI study of emotion that he can lay his hands on—a total of some 150—and performed what statisticians call a meta-analysis. The result, illustrated below, is as close as anyone has yet come to producing an emotional map of the brain.



The experience of emotion is one of the most fundamental parts of an individual's identity. Most neuroscientists now recognise six basic emotions: anger, disgust, fear, joy, sadness and surprise. Dr Wager's map is a neat illustration of how fMRI can be used to see the links between different parts of the brain that are involved in a single process.

That people like Dr Wager can now study emotion scientifically shows how far things have come. For much of the 20th century, psychology sought to purge itself of the sin of anthropomorphism—that is, inappropriately ascribing human motives and feelings to other species. The tradition known as behaviourism approached animals as “black boxes”. Behaviourists stimulated them in different ways and recorded what happened. They did not ask what the animals felt. That both stymied comparative studies of emotion and put out of the scientific arena the question of how emotion evolved. Meanwhile anthropology, in a parallel ideological fit caused by the abuses of the eugenics movement, sought to expunge the idea that human behaviour had much in the way of a genetic underpinning. This was the infamous nature/nurture debate that lingers to this day.

Two people in particular came to the rescue: Paul Ekman and Joseph LeDoux. From the 1970s onwards, Dr Ekman, a psychologist at the University of California, San Francisco, challenged the anthropologists. He was responsible for the general agreement on the six basic emotions. He showed that the facial expressions associated with these emotions are universal, and therefore almost certainly plumbed in genetically.

In the 1980s Dr LeDoux, who is at New York University, challenged the behaviourists. Instead of rejecting anthropomorphism, he embraced it—though he did so carefully, noting the crucial importance of the word “inappropriately” in the ascription of human feelings to animals. He therefore studied fear, an emotion that no zoologist would doubt that mankind shares with other species, and used some of those other species to look inside the black box of the brain.

Now, as Dr Wager's ability to collect so many research papers suggests, studying emotion is all the rage. A glance at his map shows that many emotional pathways converge on two structures called the amygdalas. These are part of the limbic system, a collection of specialised structures in the middle of the brain, and it was Dr LeDoux who demonstrated their importance in a series of experiments carried out initially on rats. He used several techniques to confirm that the amygdalas are the most active part of the brain when the subject is afraid. He also produced fear by stimulating the neurons of the amygdalas with electricity. Subsequent work has shown that the amygdalas have the same role in people. Lose parts of them, as happens sometimes as a

result of disease or surgery, and you may lose your ability to experience or recognise fear.

To start with, therefore, the amygdalas were thought of as the organs of fear. This, perhaps, is a good example of the sort of premature conclusion that critics worry about—because things turned out to be more complicated.

First, although the amygdalas do orchestrate fear, they seem to do so in the role of conductors as much as players. Certainly this emotional orchestra cannot play without the conductor, but the absence of the other instruments, whose functions are shown in Dr Wager's map, will also be noticed.

Second, the amygdalas also conduct other emotions. Since Dr LeDoux's pioneering work, further studies have linked anger, sadness and disgust with the amygdalas. They have also started to link other parts of the brain with particular emotions. Joy, for example, involves the amygdala's neighbour, the hypothalamus.

Genetics is starting to contribute to the study of emotion as well. The breakthrough came in 1993, with the discovery of a family (in the Netherlands, as it happened) that included an abnormally large number of violent criminals. The common factor in the criminal members of the family turned out to be the absence, due to a faulty gene, of an enzyme called monoamine oxidase A . This enzyme regulates a group of neurotransmitters that includes serotonin and dopamine. Serotonin- and dopamine-based neurons are both important for emotional responses.

At the time, the finding about monoamine oxidase A was widely reported as the discovery of “a gene for violence”. But violence is the expression of anger. Men without the gene were more easily angered. They had shorter fuses and were thus prone to spontaneous violent acts.

The Dutch study was followed up by one carried out in New Zealand by Terrie Moffitt, now of the Institute of Psychiatry in London. She took the nature/nurture question head on by demonstrating that the two interact, and in predictable ways. Again, the gene in question was the one for monoamine oxidase A . Like all genes, its activity is regulated by a DNA switch called a promoter. Monoamine-oxidase- A promoters come in two versions. Dr Moffitt found that a combination of one version and abuse during childhood really pushed people over the edge. The promoter alone, or abuse alone, resulted in some violent tendencies, but it was the mixture that made people really angry.

Illogical, captain

Humans share the basic emotions identified by Dr Ekman's work with other mammals. That helps to make them easy to study. But there is also a range of what are referred to, for want of a better phrase, as higher emotions. These are feelings thought to be confined, if not to humans alone, then to a small subset of large-brained mammals, several of whom are related to humans.

The list of higher emotions is not as well defined as that of the baser ones, but they include things such as guilt, embarrassment, shame and sympathy. What they have in common is that they depend not merely on what the person feeling them thinks about others, but on what the person feeling them thinks others are thinking about them. It is not the guilt or shame of the act itself, but the risk of being found out that provokes the emotion.

The evolution and function of these emotions is bound up with an area of research called theory of mind, to which this survey will return later. But, like basic emotions, the higher ones seem to have reliable neurological circuits whose location can be identified by fMRI.

Yoshiro Okubo, of Nippon Medical School in Japan, for example, has used fMRI to look at guilt and embarrassment. It is not easy to evoke such feelings in someone lying inside an MRI machine, but Dr Okubo thinks he has managed it. The results suggest that these emotions are handled in the medial prefrontal cortex (the middle of the front of the frontal lobe), the left posterior superior temporal sulcus (one of the furrows towards the side of the brain) and the visual cortex (towards the back of the brain).

It is surely no coincidence that much of the activity Dr Okubo found is in that characteristically human part of the brain, the enlarged cerebral cortex, rather than in the limbic system. And, as Dr Okubo points out, some of these areas are also associated with theory of mind.

The involvement of the frontal lobes is significant for another reason, though: it is the place where Phineas Gage took his hit. And that throws light on the question of what, exactly, emotions are for.

It is widely assumed that emotion and rationality are somehow opposed to each other, and that rational decisions are better than emotional ones. In fact, emotion and reason work closely together, as has been demonstrated by Antonio Damasio, the man who revived Gage's 19th-century fame in the 20th century.

Dr Damasio, who now works at the University of Southern California, is both a clinician and a researcher. He draws a parallel between Gage's case and those of some of his own patients. In particular, he has a patient called Elliot (in neuroscience, patients are often referred to by single names or initials to preserve their privacy) whose frontal lobe was damaged by a brain tumour. When the tumour was removed by surgeons, the damaged tissue was taken out too.

Like Gage, Elliot was a responsible individual with a good job (and in his case a family, too) before he suffered his brain damage. The outcome was somewhat different in that Elliot did not become a foul-mouthed wastrel; rather, he became obsessed with detail and stopped being able to make sensible decisions. The overall result was similar, though. He lost his job and his wife and ended up an outcast.

At first, Dr Damasio thought that Elliot's tumour had damaged his reason (both lesion studies and fMRI have shown that the frontal cortex is also the seat of the brain's reasoning powers). Tests, however, showed that what had gone instead were his emotions. Elliot no longer felt anything, and although he could summarise the choices available in a given situation as well as anyone else, without his emotions to guide him he could not actually make a choice. And, as probably happened with Gage, that loss of emotion also changed his self.

The survival value of things like fear, disgust and joy is obvious: run away from it; don't eat it; do more of it. But the idea that emotions shape all activity in adaptive ways is quite a subtle one. Rationality has its place. In the end, though, as fans of "Star Trek" will remember, it is Captain Kirk, the emotion-ridden human, not Mr Spock, the emotionless Vulcan, who has the nous to run the spaceship.

Questions:

1. Look up somewhere else what a fMRI is. That is, a functional MRI machine. Briefly explain how it works.
2. What are the six basic emotions that appear to be genetic? How did Dr Paul Ekman 'prove' this?
3. What organ of the brain is linked to fear? What musical analogy is made to describe its role? Which organ seems to be linked to joy?
4. What were the findings of a Dutch study on a gene for violence?
5. What do higher emotions seem to have in common?

6. Summarize the neurological case of Elliot and relate it to the title of this article.