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How the gut feeling shapes fear

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Gut feeling: the gut influences brain processes involved in emotions like fear. Credit: Fotolia / Montage: ETH Zurich

We are all familiar with that uncomfortable feeling in our stomach when faced with a threatening situation. By studying rats, researchers at ETH Zurich have been able to prove for the first time that our 'gut instinct' has a significant impact on how we react to fear.

An unlit, deserted car park at night, footsteps in the gloom. The heart beats faster and the stomach ties itself in knots. We often feel threatening situations in our stomachs. While the brain has long been viewed as the centre of all emotions, researchers are increasingly trying to get to the bottom of this proverbial gut instinct.

It is not only the brain that controls processes in our abdominal cavity; our stomach also sends signals back to the brain. At the heart of this dialogue between the brain and abdomen is the vagus nerve, which transmits signals in both directions – from the brain to our internal organs (via the so called efferent nerves) and from the stomach back to our brain (via the afferent nerves). By cutting the afferent nerve fibres in rats, a team of scientists led by Urs Meyer, a researcher in the Group of ETH Zurich professor Wolfgang Langhans, turned this two-way communication into a one-way street, enabling the researchers to get to the bottom of the role played by gut instinct. In the test animals, the brain was still able to control processes in the abdomen, but no longer received any signals from the other direction.

Less fear without gut instinct

In the behavioural studies, the researchers determined that the rats were less wary of open spaces and bright lights compared with controlled rats with an intact vagus nerve. "The innate response to fear appears to be influenced significantly by signals sent from the stomach to the brain," says Meyer.

Nevertheless, the loss of their gut instinct did not make the rats completely fearless: the situation for learned fear behaviour looked different. In a conditioning experiment, the rats learned to link a neutral acoustic stimulus – a sound – to an unpleasant experience. Here, the signal path between the stomach and brain appeared to play no role, with the test animals learning the association as well as the control animals. If, however, the researchers switched from a negative to a neutral stimulus, the rats without gut instinct required significantly longer to associate the sound with the new, neutral situation. This also fits with the results of a recently published study conducted by other researchers, which found that stimulation of the vagus nerve facilitates relearning, says Meyer.

These findings are also of interest to the field of psychiatry, as post-traumatic stress disorder (PTSD), for example, is linked to the association of neutral stimuli with fear triggered by extreme experiences. Stimulation of the vagus nerve could help people with PTSD to once more associate the triggering stimuli with neutral experiences. Vagus nerve stimulation is already used today to treat epilepsy and, in some cases, depression.

Stomach influences signalling in the brain

"A lower level of innate fear, but a longer retention of learned fear – this may sound contradictory," says Meyer. However, innate and conditioned fear are two different behavioural domains in which different signalling systems in the brain are involved. On closer investigation of the rats' brains, the researchers found that the loss of signals from the abdomen changes the production of certain signalling substances, so called neurotransmitters, in the brain.

"We were able to show for the first time that the selective interruption of the signal path from the stomach to the brain changed complex behavioural patterns. This has traditionally been attributed to the brain alone," says Meyer. The study shows clearly that the stomach also has a say in how we respond to fear; however, what it says, i.e. precisely what it signals, is not yet clear. The researchers hope, however, that they will be able to further clarify the role of the vagus nerve and the dialogue between brain and body in future studies.

More information: Klarer M, Arnold M, Günther L, Winter C, Langhans W, Meyer U: Gut Vagal Afferents Differentially Modulate Innate Anxiety and Learned Fear. The *Journal of Neuroscience*, 21 May 2014. DOI: 10.1523/JNEUROSCI.0252-14.2014

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