The face of a mouse reveals its emotions: study

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The facial expression of a mouse reveals its feelings, providing a possibility for researchers to study the underlying neuronal mechanisms of emotions. Credit: MPI of Neurobiology / Kuhl

Researchers at the Max Planck Institute of Neurobiology are the first to describe emotional facial expressions for mice. Similar to humans, mouse facial expressions change when it tastes something sweet or bitter, or when it becomes anxious. With this new possibility of measuring the emotions of mice, neurobiologists can investigate the basic mechanisms of how emotions are generated and processed in the brain.

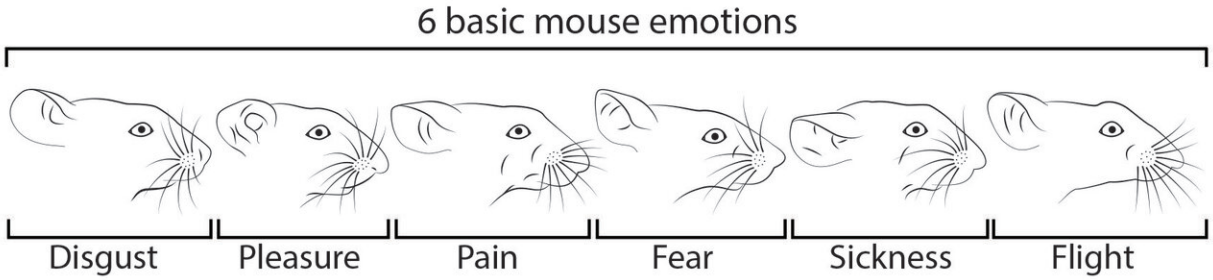
Pleasure, disgust, fear—the facial expressions that reflect these emotions are the same in every human. For example, if we are disgusted by something, our eyes become narrower, our nose wrinkles, and our upper lip distorts asymmetrically. Even newborn babies react with distinct facial expressions when they are sad, happy or disgusted. We also think to recognize feelings in the facial expressions of our pets. In contrast, the faces of other animals can appear expressionless to us. This is wrong, as the Max Planck scientists now show.

Using machine vision, the researchers were able to reliably link five emotional states to the facial expressions of mice: pleasure, disgust, nausea, pain and fear were clearly distinguishable for the computer algorithms. They could even measure the relative strength of these emotions.

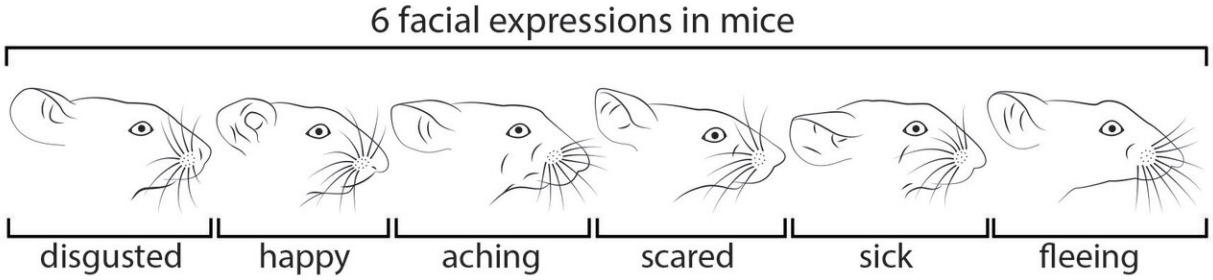
Joyful expression

The study shows that the facial expressions of mice are not just reactions to the environment. Expressions reflect the emotional value of the trigger. "Mice that licked a sugar solution when they were thirsty showed a much more joyful facial expression than satiated mice," explains Nadine Gogolla, who led the study. Meanwhile, mice that tasted a slightly salty solution showed a "satisfied" expression, while a very salty solution led to a "disgusted" face. From these and other experiments, the researchers conclude that, uncoupled from the sensory stimulus, facial expressions actually reflect the inner, individual character of an emotion.

Emotions, however, are not simply a reaction to an external stimulus—they arise through mechanisms in the brain itself. So the researchers next investigated how neuronal activity in different brain regions affects facial expressions. The neurobiologists were able to evoke different emotional facial expressions when they light-activated specific brain areas known to play a role in emotional processing.



Mice exhibit stereotyped facial expressions which allow the classification of distinct emotional states. Credit: Julia Kuhl



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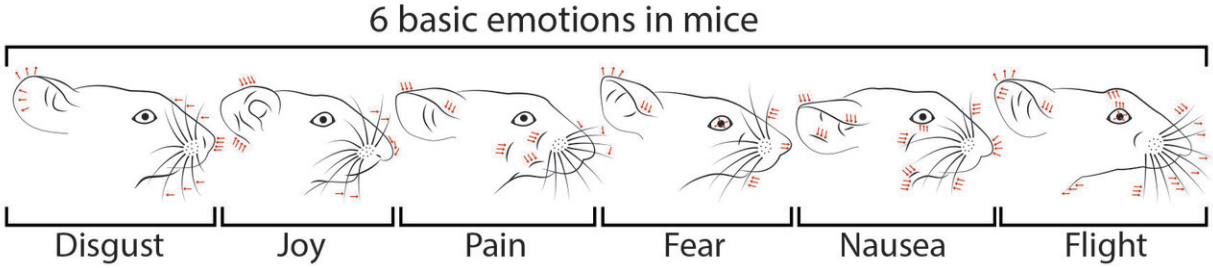

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Mechanisms behind emotions

The main benefit of the discovery of mouse facial expressions is that it is now possible to identify mechanisms giving rise to emotions. This was previously a problem: Without a reliable measurement of emotions, it has been difficult to study their origins in the brain. "We humans may notice a subtle facial change in the mice, but we can only recognize the emotion behind it with a great deal of experience, and can hardly ever determine its intensity," says Nejc Dolensek, the study's lead author. "With our automated face recognition system, we can now measure the intensity and nature of an emotion on a timescale of milliseconds and compare it to the neuronal activity in relevant brain areas." One such brain area is the insular cortex, which is associated with emotional behavior and the perception of emotions in animals and humans.

When the scientists measured the activity of individual neurons using two-photon microscopy and simultaneously recorded the emotional facial expressions of the mouse, something astonishing came to light: Individual neurons of the insular cortex reacted with the same strength and at the exactly same time as the mouse's facial expression. In addition, each individual neuron was linked to only one single emotion.

These results suggest the existence of "emotion neurons," each reflecting a specific sensation—at least in the insular cortex. "By recording facial expressions, we can now investigate the fundamental neuronal mechanisms behind emotions in the mouse animal model," explains Nadine Gogolla. "This is an important prerequisite for the investigation

of emotions and possible disorders in their processing, such as in anxiety disorders or depression."

More information: N. Dolensek el al., "Facial expressions of emotion states and their neuronal correlates in mice," *Science* (2020). science.sciencemag.org/cgi/doi … 1126/science.aaz9468

B. Girard el al., "Revealing animal emotions," *Science* (2020). science.sciencemag.org/cgi/doi … 1126/science.abb2796

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