The neural processes of evaluating the emotions of others

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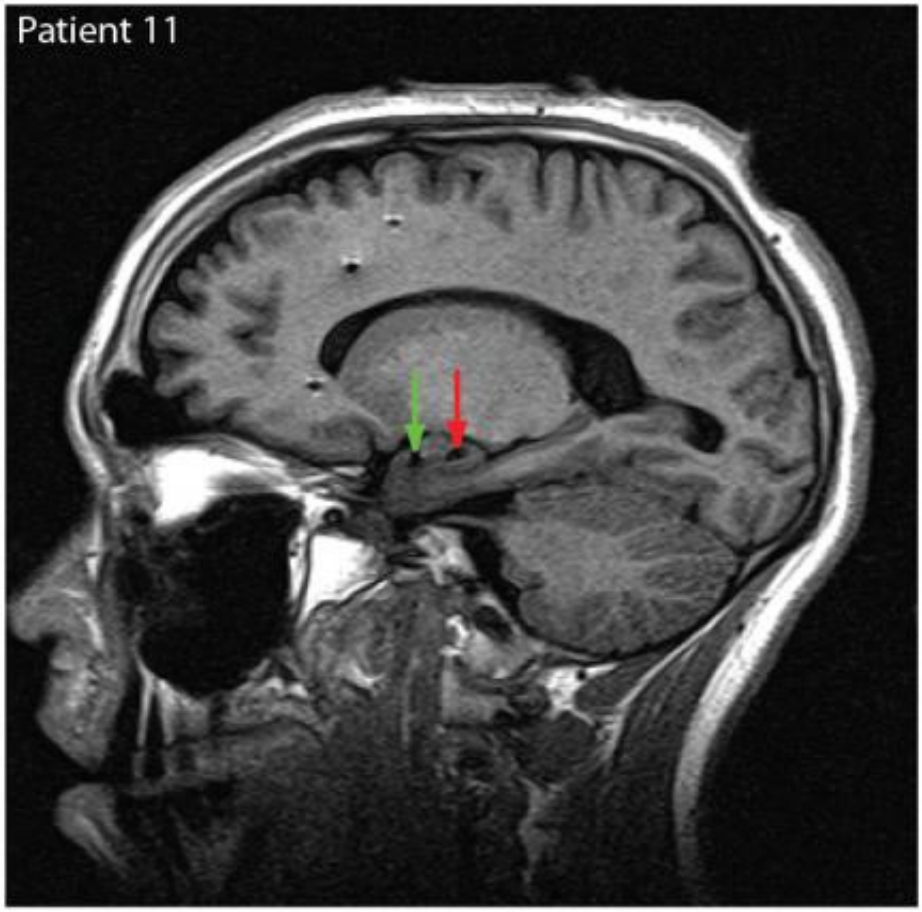

Credit: Ralph Adolphs / Caltech

When evaluating another person's emotions – happy, sad, angry, afraid – humans take cues from facial expressions. Neurons in a part of the brain

called the amygdala "fire" in response to the visual stimulation as information is processed by the retina, the amygdala and a network of interconnected brain structures. Some of these regions respond just to the actual features of the face, whereas others respond to how things appear to the viewer, but it is unknown where in the brain this difference arises.

Although the amygdala's importance in face recognition and emotional assessment is well-known, little is understood about how these processes work, but research led by investigators at Cedars-Sinai and the California Institute of Technology has found that at least some of the brain cells that specialize in recognizing emotions may represent judgments based on the viewer's preconceptions rather than the true emotion being expressed.

With colleagues from Huntington Memorial Hospital, using electrodes placed deep in the brain for unrelated diagnostic purposes, investigators recorded electrical activity of individual neurons and found a subset that were "emotion-selective" because their responses distinguished between happy and fearful faces.

Patients were shown pictures of faces whose emotion was difficult to recognize because only parts of the features were clearly visible. Some neurons were more active to faces showing fear, whereas others were more active to happy faces.

"In these instances, the patients correctly judged the expressed emotion," said Ueli Rutishauser, PhD, assistant professor of neurosurgery and director of human neurophysiology research at Cedars-Sinai, senior author of an article published online the week of June 30 in the Early Edition of *Proceedings of the National Academy of Sciences*.

"But we found that these neurons also responded similarly during

incorrect trials, when patients made errors about the actual emotion shown on the faces," Rutishauser added. "When a fear face was incorrectly judged as happy, the neurons responded as if a happy face was correctly judged as happy – in a sense, "correctly" representing the patient's incorrect judgment. When a happy face was incorrectly judged as a fear face, the neurons responded as if a fear face had been correctly judged as fear – again, reinforcing the 'correctness' of the incorrect decision. This tells us that the neurons' responses were based on the subjective, perceived judgments that the patients made rather than on the 'ground truth' of the emotion shown in the stimulus."

When the investigators recorded neurons in the hippocampus – a structure adjacent to the amygdala that also is involved in processing of thoughts, emotions and memories – they found that the cells responded to the visual stimuli, but those responses did not reflect the patients' subjective judgment.

Abnormal functioning of the amygdala is implicated in several neurological diseases, such as autism, phobias, post-traumatic stress disorder and anxiety. According to the authors, this study provides an intriguing possibility for why amygdala dysfunction can lead to anxiety or unprovoked fear: Despite a normal sensory input – such as a happy-looking person – the internal representation of emotion in the amygdala is driven by the subjectively perceived emotion, which is fear in this case.

"To our knowledge, these findings are novel, in that they show that the response of emotion-sensitive neurons in the amygdala is biased toward the person's subjective judgment of emotions instead of simply responding to the actual features of the stimulus," said Shuo Wang, PhD, a postdoctoral scholar at Caltech and first author of the article. "We've known that the amygdala plays an important role in face and emotion recognition, but these results suggest that it integrates sensory

information about faces. It may be that subjective perceptions of facial emotion are formed through repeated cycles of processing between the amygdala, the temporal cortex and other brain structures that shape a person's values and social perspectives."

The firing of a single neuron is believed to be the basic unit of brain computation, and these studies are accomplished through the collaboration of neuroscientists and neurosurgeons, with the consent and participation of patients who undergo deep brain electrode placement for diagnostic or treatment procedures.

"Single neuron studies have been performed in animals, but conducting them in human subjects gives us an opportunity to get direct feedback, without having to make assumptions when interpreting animal responses. The amygdala is a routine target for depth electrodes to localize epileptic seizures, and this provides the opportunity to explore this structure that is vitally important in the processing of emotions," said Adam Mamelak, MD, professor of neurosurgery and director of functional neurosurgery at Cedars-Sinai, one of the article's authors.

According to Ralph Adolphs, PhD, Bren professor of psychology and neuroscience at Caltech, a contributing author, "Most data relevant to understanding psychiatric illness is derived from studies that use functional magnetic resonance imaging. What we desperately need is a more microscopic level as well, and these single-unit data we can record in neurosurgical patients offer a unique study opportunity."

Rutishauser added, "Our group is focused on pursuing neurosurgical approaches that allow us to study individual neurons. We believe this research can provide valuable new knowledge on the function of the human nervous system that would otherwise be unobtainable."

More information: Shuo Wang, Oana Tudusciuc, Adam N. Mamelak,

Ian B. Ross, Ralph Adolphs, and Ueli Rutishauser. "Neurons in the human amygdala selective for perceived emotion." *PNAS* 2014 ; published ahead of print June 30, 2014, DOI: 10.1073/pnas.1323342111