Learning in the absence of external feedback

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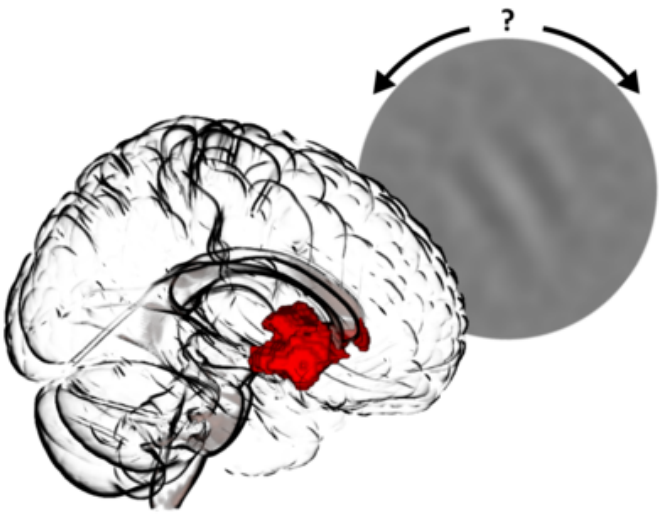

Participants perform a visual learning task: their level of confidence regarding the orientation of a particular stimulus activates a specific area within the brain's limbic system. Copyright Charité.

Rewards act as external factors that influence and reinforce learning processes. Researchers from Charité - Universitätsmedizin Berlin have now been able to show that the brain can produce its own learning signals in cases where no such external feedback is available. A report on the mechanisms underlying these self-generated feedback signals has been published in the current volume of *eLife*, and shows clear parallels between the neurobiological processes involved in learning based on external and self-generated feedback.

While learning forms an integral part of our day-to-day lives, there are only certain instances in which we receive external feedback about our performance. A group of researchers, led by Prof. Dr. Philipp Sterzer from the Visual Perception Working Group at Charité's Department of Psychiatry and Psychotherapy, have investigated the neurobiological basis of learning in the absence of external feedback. Using functional magnetic resonance imaging, the researchers measured neural activity levels in the brains of healthy volunteers as they performed challenging perceptual learning tasks. Instead of receiving feedback about their performance, participants were asked to report levels of confidence in their assessment of visual stimuli.

"Our experiments showed that the brain activity levels recorded during confidence-based learning mirrored many of the features previously recorded in relation to external feedback-based learning," says the study's first author, Dr. Matthias Guggenmos. Earlier studies on external, reward-based feedback had shown that participants' brain activity levels at the start of a task reflected their prediction about the upcoming reward. Once the reward had been received, a 'prediction error' was recorded reflecting the difference between predicted and actual reward. As part of the current study, the researchers were able to record an identical response pattern in learning processes not involving external feedback. In this study, the prediction signal corresponded to the participant's own level of confidence, while the prediction error corresponded to the surprise experienced at the discrepancy in the actual level of confidence. "These remarkable parallels suggest that subjective confidence - just like external reward - is a general learning signal, and that it may also play an important role in other types of learning that do not involve feedback, such as school homework assignments," says Dr. Guggenmos.

The study was based on the hypothesis that, in the absence of external signals, the brain may be capable of generating its own feedback signals. "Our assumption was that the level of subjective confidence experienced in relation to one's own perception might be a measure of self-generated feedback," explains Dr. Guggenmos, adding: "The general idea is that the brain reinforces perceptual processes that are associated with a high level of

confidence, while avoiding processes associated with a low level of confidence." The researchers were able to explain the participants' answers by using a mathematical model in which external feedback was replaced with subjective confidence. Results also showed a systematic relationship between the strength of the neural confidence signal measured and the actual learning success recorded during the perceptual task, suggesting that confidence signals exert a measurable effect on perceptual learning.

More information: Matthias Guggenmos et al. Mesolimbic confidence signals guide perceptual learning in the absence of external feedback, *eLife* (2016). DOI: 10.7554/eLife.13388