How serotonin balances communication within the brain

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Dirk Jancke. Credit: RUB, Kramer

The brain is steadily engaged in thought. These internal communications are also usually bombarded with external sensory events. Hence, the impact of the two neuronal processes need to be permanently fine-tuned

to avoid their imbalance. A team of scientists at the Ruhr-Universität Bochum (RUB) has now revealed the role of the neurotransmitter serotonin in this mechanism. They discovered that distinct serotonergic receptor types control the gain of both streams of information in a separable manner. Their findings may facilitate new concepts of diagnosis and therapies for neuronal disorders related to malfunction of the serotonin system. The study is published online in the open access journal *eLife* on 7 April 2020.

Impacting on different streams of information in the brain

Dr. Dirk Jancke, head of the Optical Imaging Group at the Institute of Neural Computation, says, "Imagine sitting with your family at dinner, and a heated debate is going on about how to properly organize some internal affairs. Suddenly, the phone starts ringing; you are picking up while family discussion goes on. In order to understand the calling party correctly, the crowd in the back must speak lower or the caller needs to speak up. Thus, the loudness of each internal background conversation and external call need to be properly adjusted to ensure non-interfered, separable information transfer." As in this anecdote, comparable brain processes involve serotonin.

Serotonin is a neurotransmitter of the central nervous system, commonly called the "happy hormone" because it contributes to changes in brain state and is often associated with effects on mood. The study of the RUB team now demonstrates that serotonin participates also in the scaling of current sensory input and ongoing brain signals.

Controlling neuronal release of serotonin with light

The RUB neuroscientists discovered the underlying mechanisms in

experiments that investigated cortical processing of visual information. For their study, they used genetically modified mice in which the release of serotonin could be controlled by light. This mouse line was developed by the group of Professor Stefan Herlitze, Department of General Zoology and Neurobiology, to enable specific activation of serotonergic neurons by an implanted light fiber.

Combining this technique with optical imaging, the RUB team found that increasing levels of serotonin in the visual brain leads to concurrent suppression of ongoing activity and activity evoked by visual stimuli. Two types of receptors played a distinct major role here. "This was surprising to us, because both receptors are not only co-expressed in specific neurons, but also widely distributed across different cell types in the brain," says Zohre Azimi, first author of the study.

Separable action of these receptors allows distinct modulations of information carrying internal brain communication and evoked sensory signals. Low serotonin levels, as they typically occur during sleep at night, favor internal brain communication, and thus, may promote important functions of dreaming. "Dysfunction in the interplay of these receptors, on the other hand, harbors the risk of an overemphasis of either internally or externally driven information channels," says Jancke. For example, irregular 5-HT receptor distributions caused by genetic predisposition may become manifest in an imbalanced perception of inner and outside world, similar as seen in clinical pictures of depression and autism.

The scientists hope that their findings contribute to a better understanding of how serotonin affects fundamental brain processes. In turn, their study may trigger future research in developing receptor-specific drugs that benefit patients with serotonin-related psychiatric diseases.

More information: Zohre Azimi et al. Separable gain control of ongoing and evoked activity in the visual cortex by serotonergic input, *eLife* (2020). DOI: 10.7554/eLife.53552