How fair sanctions are orchestrated in the brain

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Civilized human cohabitation requires us to respect elementary social norms. We guarantee compliance with these norms with our willingness to punish norm violations – often even at our own expense. This behavior goes against our own economic self-interest and requires us to control our egoistic impulses.

Innovative combination of methods

In collaboration with Professor Ernst Fehr, Dr. Thomas Baumgartner and Professor Daria Knoch reveal the neuronal networks behind self-control in an article recently published in *Nature Neuroscience*. For the purposes of their study, they combined the transcranial magnetic stimulation (TMS) method with functional magnetic resonance imaging (fMRI).

Interaction between two frontal brain regions

The results of the study show that people only punish norm violations at their own expense if the dorsolateral prefrontal cortex – an important area for control located at the front of the brain – is activated. This control entity must also interact with another frontal region, the ventromedial prefrontal cortex, for punishment to occur.

The communication between these two frontal regions of the brain is also interesting in light of earlier fMRI studies, which showed that the

ventromedial prefrontal cortex encodes the subjective value of consumer goods and normative behavior. As neuroscientist Thomas Baumgartner explains, it seems plausible that this brain region might also encode the subjective value of a sanction. This value increases through the communication with the dorsolateral prefrontal cortex. "Using brain stimulation, we were able to demonstrate that the communication between the two brain regions becomes more difficult if the activity in the dorsolateral prefrontal cortex is reduced. This in turn makes punishing norm violations at your own expense significantly more difficult."

Therapeutic benefits

The results could be important in the therapeutic use of the non-invasive brain-stimulation method in psychiatric and forensic patients. Patients who exhibit strong anti-social behavior also frequently display reduced activity in the ventromedial prefrontal cortex. This region of the brain, however, is not directly accessible for non-invasive brain stimulation, as its location is too deep inside the brain. The results of the current study suggest that the activity in this region of the brain could be increased if the activity in the dorsolateral prefrontal cortex were increased with the aid of brain stimulation. "This indirectly induced increase in the activity of the frontal brain regions could help improve prosocial and fair behavior in these patients," concludes Daria Knoch.

Transcranial magnetic stimulation (TMS) and functional magnetic resonance imaging (fMRI)

TMS reduces the excitability of an area of the brain temporarily and painlessly. The researchers used this short-term impairment of an area of the brain to examine subjects' behavior when they had to decide whether to punish a partner's unfair behavior in a negotiation experiment. TMS

enables causal conclusions as to whether a particular area of the brain plays a decisive role in behavior, including whether sanctions will occur. Brain areas often work in a network, however, and rarely in isolation during such a complex process. While fMRI can be used to measure the activity of these networks, the method does not allow any causal conclusions to be drawn. Only a combination of the two methods thus permits the determination of the neuronal networks that play a causal role in sanctioning at one's own expense.

More information: Thomas Baumgartner, Daria Knoch, Philine Hotz, Christoph Eisenegger und Ernst Fehr: Dorsolateral and ventromedial prefrontal cortex orchestrate normative choice, in: Nature Neuroscience, 2 October 2011, DOI: 10.1038/nn.2933