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How the carrot approach facilitates learning

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People who are rewarded for making correct decisions learn quickly. While the "carrot" approach may produce favourable results, little is understood about how rewards facilitate the learning process.

Now, in a paper published this week in the online open-access journal PLoS Biology, a team headed by Dr. Burkhard Pleger of the Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, and the University College London have demonstrated that the "reward effect" not only supports the improvement of higher cognitive abilities, but also how brain function in the cortex can be enhanced. Intriguingly, they see that the reward effect can be strengthened using dopaminergic compounds. Targeted manipulation of dopamine levels, thereby enhancing the "teaching signal" in the brain, could open up new possibilities in the treatment of patients, for example, after a stroke.

Previous work has shown that if a decision leads to a successful outcome, it is registered in the brain's reward system. The reward stimulus is then relayed to the area of the brain which was responsible for making the decision. In this way, the brain optimises its processes for improved performance each time. "It was not known until now, however, whether this mechanism also applied to functions of the somatosensory cortex, which process the skin's sense of touch, for instance," explains Dr. Pleger.

To answer this question, the researchers designed a "game" for their subjects. Electrodes were attached to both index fingers of the subjects. In each trial, two electric currents, each with a different frequency, were successively applied to subjects' fingers via the electrodes. Subjects had to decide whether the first or second electric current had a higher frequency. If they were correct, a monetary reward was displayed on a screen. The fact that the reward effect works when it is displayed visually had already been confirmed in an earlier study. The amount of the reward was varied from trial to trial. The result: depending on the size of the reward, the subjects were able to subsequently make the correct decision with improved accuracy. "As well as the effects on higher cognitive processes which were already known, it shows that the reward effect also influences somatosensory processes," says Dr. Pleger. "It turns out to be stronge r, the higher the reward."

In addition to this, the researchers were interested in the role of the neural transmitter dopamine. Therefore, subjects were divided into three groups before the experiment began. The researchers administered the dopaminergic compound Levopoda to the first group, and the second group received the dopamine inhibitor Haloperidol. The third group were treated with a placebo as a control. The effect was clear-cut: The effect of the reward was greatest in group whose dopamine levels had been raised by Levopoda. Subjects in the placebo group also learned with each trial, albeit by less. The reward effect was totally absent in the group of subjects who received the dopamine inhibitor.

"Apparently, the interaction between the regions of the reward system and the somatosensory cortex are mediated by the transmitter dopamine," says Pleger. This discovery opens up interesting possible uses for medicine. The researchers write that in the future, targeted use of dopaminergic compounds could be used to aid the rehabilitation of stroke patients, for example. In theory, applications for pharmaceutical "learning boosters" are also conceivable. However, caution is needed in this. "A raised dopamine level in the brain has already been identified as the cause of mental illnesses such as schizophrenia," warns Dr. Pleger, "so too much is also not good, and can even be dangerous."

More information: Pleger B, Ruff CC, Blankenburg F, Klöppel S, Driver J, et al. (2009) Influence of Dopaminergically Mediated Reward on Somatosensory Decision-Making. *PLoS Biol* 7(7): e1000164. doi:10.1371/journal.pbio.1000164

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