Reward linked to image is enough to activate brain's visual cortex

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Once rhesus monkeys learn to associate a picture with a reward, the reward by itself becomes enough to alter the activity in the monkeys' visual cortex. This finding was made by neurophysiologists Wim Vanduffel and John Arsenault (KU Leuven and Harvard Medical School) and American colleagues using functional brain scans and was published recently in the leading journal *Neuron*.

Our visual perception is not determined solely by retinal activity. Other factors also influence the processing of visual signals in the brain. "Selective attention is one such factor," says Professor Wim Vanduffel. "The more attention you pay to a stimulus, the better your visual perception is and the more effective your visual cortex is at processing that stimulus. Another factor is the reward value of a stimulus: when a visual signal becomes associated with a reward, it affects our processing of that visual signal. In this study, we wanted to investigate how a reward influences activity in the visual cortex."

To do this, the researchers used a variant of Pavlov's well-known conditioning experiment: "Think of Pavlov giving a dog a treat after ringing a bell. The bell is the stimulus and the food is the reward. Eventually the dogs learned to associate the bell with the food and salivated at the sound of the bell alone. Essentially, Pavlov removed the reward but kept the stimulus. In this study, we removed the stimulus but kept the reward."

In the study, the rhesus monkeys first encountered images projected on a screen followed by a juice reward (classical conditioning). Later, the monkeys received juice rewards while viewing a blank screen. fMRI brain scans taken during this experiment showed that the visual cortex of the monkeys was activated by being rewarded in the absence of any image.

Importantly, these activations were not spread throughout the whole visual system but were instead confined to the specific brain regions responsible for processing the exact stimulus used earlier during conditioning. This result shows that information about rewards is being sent to the visual cortex to indicate which stimuli have been associated with rewards.

Equally surprising, these reward-only trials were found to strengthen the cue-reward associations. This is more or less the equivalent to giving Pavlov's dog an extra treat after a conditioning session and noticing the next day that he salivates twice as much as before. More generally, this result suggests that rewards can be associated with stimuli over longer time scales than previously thought.

Why does the visual cortex react selectively in the absence of a visual stimulus on the retina? One potential explanation is dopamine. "Dopamine is a signalling chemical (neurotransmitter) in nerve cells and plays an important role in processing rewards, motivation, and motor functions. Dopamine's role in reward signalling is the reason some Parkinson's patients fall into gambling addiction after taking dopamine-increasing drugs. Aware of dopamine's role in reward, we re-ran our experiments after giving the monkeys a small dose of a drug that blocks dopamine signalling. We found that the activations in the visual cortex were reduced by the dopamine blocker. What's likely happening here is that a reward signal is being sent to the visual cortex via dopamine," says Professor Vanduffel.

The study used fMRI (functional Magnetic Resonance Imaging) scans to visualise brain activity. fMRI scans map functional activity in the brain by detecting changes in blood flow. The oxygen content and the amount of blood in a given brain area vary according to the brain activity associated with a given task. In this way, task-specific activity can be tracked.

More information: "Dopaminergic reward signals selectively decrease fMRI activity in primate visual cortex" www.cell.com/neuron/abstract/S0896-6273(13)00052-4

Provided by KU Leuven