Car or pedestrian -- How we can follow objects with our eyes

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When an object moves fast, we follow it with our eyes: our brain correspondingly calculates the speed of the object and adapts our eye movement to it. This in itself is an enormous achievement, yet our brain can do even more than that. In the real world, a car will typically accelerate or brake faster than, say, a pedestrian. But the control of eye movement in fact responds more sensitively to changes in the speed of fast moving objects than slow moving objects.

"Gain control" is the name for this phenomenon, which has been known for some time now, but which has now just been recently analyzed more closely by a group working with associate professor Dr. Stefan Glasauer from the Bernstein Center for Computational Neuroscience and Ludwig-Maximilians-Universität (LMU) München, Germany. The researchers determined the location in the brain where gain control is calculated, and what neuronal networks are behind this complex process. The results were postulated in a mathematical model and experimentally verified – and could be of great help in the diagnosis of eye movement disorders.

Eye movement control is not exactly a new field of research. We already know, for example, that different regions of the cerebral cortex are involved in eye tracking movements. These include "Area MST" and the so-called frontal eye fields, or FEFs for short. Nerve cells in Area MST mainly reflect the speed of the eye or target motion, whereas cells in the FEFs mainly respond to changes in speed. These insights have been obtained mostly from human behavioral experiments and from neurophysiological studies.

But the aim of the scientists under the direction of Glasauer, his coworker Ulrich Nuding and Professor Ulrich Büttner of the Neurological Clinic at LMU Munich was now to amalgamate these insights into a computer model that actually explains this eye movement control. The new model simulates the most important circuits required for controlling eye tracking movement. In Area MST, the speed of the target object is calculated and compared with the momentary eye speed in order to adapt it accordingly. The FEFs are the actual location where the gain control takes place; this is where the sensitivity of eye movement to changes in speed is defined.

In order to verify their models in studies, the scientists joined forces with colleagues at University College in London: they had subjects follow a dot on a screen with their eyes. The activity of the FEFs was briefly disrupted by so-called "transcranial magnetic stimulation". This technology can influence individual, targeted areas of the brain for a few seconds. The experiments did indeed confirm the predictions of the models: as long as the observed object was moving at a constant speed, a disruption of the FEFs had little effect on eye movement control.

The sensitivity of the eye movement to changes in speed, on the other hand, did not increase sufficiently at higher speeds when the FEFs were disrupted. It follows that the gain control is determined in the FEFs depending on the speed of the eye or the target. In short, the faster an object moves, the greater the adaptability. "With this, we have managed for the first time to explain the purpose of parallel anatomic paths in neuronal processing for eye tracking," says Glasauer. Sensitivity control also exhibits interesting parallels to visual attention control, for which the FEFs are also important. Therefore, it can very well be regarded as an attention mechanism within the eye tracking system.

Source: Ludwig-Maximilians-Universität München