Everyday clairvoyance: How your brain makes near-future predictions

August 17 2011

Every day we make thousands of tiny predictions — when the bus will arrive, who is knocking on the door, whether the dropped glass will break. Now, in one of the first studies of its kind, researchers at Washington University in St. Louis are beginning to unravel the process by which the brain makes these everyday prognostications.

While this might sound like a boon to day traders, coaches and gypsy fortune tellers, people with early stages of neurological diseases such as schizophrenia, Alzheimer's and Parkinson's diseases could someday benefit from this research. In these maladies, sufferers have difficulty segmenting events in their environment from the normal stream of consciousness that constantly surrounds them.

The researchers focused on the mid-brain dopamine system (MDS), an evolutionarily ancient system that provides signals to the rest of the brain when unexpected events occur. Using functional MRI (fMRI), they found that this system encodes prediction error when viewers are forced to choose what will happen next in a video of an everyday event.

Predicting the near future is vital in guiding behavior and is a key component of theories of perception, language processing and learning, says Jeffrey M. Zacks, PhD, WUSTL associate professor of psychology in Arts & Sciences and lead author of a paper on the study in a forthcoming issue of the *Journal of Cognitive Neuroscience*.

"It's valuable to be able to run away when the lion lunges at you, but it's super-valuable to be able to hop out of the way before the lion jumps," Zacks says. "It's a big adaptive advantage to look just a little bit over the horizon."

Zacks and his colleagues are building a theory of how predictive perception works. At the core of the theory is the belief that a good part of predicting the future is the maintenance of a mental model of what is happening now. Now and then, this model needs updating, especially when the environment changes unpredictably.

"When we watch everyday activity unfold around us, we make predictions about what will happen a few seconds out," Zacks says. "Most of the time, our predictions are right.

"Successfull predictions are associated with the subjective experience of a smooth stream of consciousness. But a few times a minute, our predictions come out wrong and then we perceive a break in the stream of consciousness, accompanied by an uptick in activity of primitive parts of the brain involved with the MDS that regulate attention and adaptation to unpredicted changes."

Zacks tested healthy young volunteers who were shown movies of everyday events such as washing a car, building a LEGO model or washing clothes. The movie would be watched for a while, and then it was stopped.

Participants then were asked to predict what would happen five seconds later when the movie was re-started by selecting a picture that showed what would happen, and avoiding similar pictures that did not correspond to what would happen.

Half of the time, the movie was stopped just before an event boundary, when a new event was just about to start. The other half of the time, the movie was stopped in the middle of an event. The researchers found that participants were more than 90 percent correct in predicting activity within the event, but less than 80 percent correct in predicting across the event boundary. They were also less confident in their predictions.

"This is the point where they are trying hardest to predict the future," Zacks says. "It's harder across the event boundary, and they know that they are having trouble. When the film is stopped, the participants are heading into the time when prediction error is starting to surge. That is, they are noting that a possible error is starting to happen. And that shakes their confidence. They're thinking, 'Do I really know what's going to happen next?' "

Zacks and his group were keenly interested in what the participants' brains were doing as they tried to predict into a new event.

In the functional MRI experiment, Zacks and his colleagues saw significant activity in several midbrain regions, among them the substantia nigra — "ground zero for the dopamine signaling system" — and in a set of nuclei called the striatum.

The substantia nigra, Zacks says, is the part of the brain hit hardest by Parkinson's disease, and is important for controlling movement and making adaptive decisions.

Brain activity in this experiment was revealed by fMRI at two critical points: when subjects tried to make their choice, and immediately after feedback on the correctness or incorrectness of their answers.

Mid-brain responses "really light up at hard times, like crossing the event boundary and when the subjects were told that they had made the wrong choice," Zacks says.

Zacks says the experiments provide a "crisp test" of his laboratory's prediction theory. They also offer hope of targeting these prediction-based updating mechanisms to better diagnose early stage neurological diseases and provide tools to help patients.

Provided by Washington University in St. Louis