UC Berkeley scientists pinpoint how brain tracks fast-moving baseball pitches and tennis serves

By Lisa M. Krieger lkrieger@mercurynews.com
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The human brain is far slower than a Major League fastball or a blistering tennis serve -- but it has figured out a workaround.

New research by UC Berkeley scientists solves a puzzle that has long mystified anyone who has watched, in awe, as elite athletes respond to incoming balls that can surpass 90 mph.

The brain perceives speeding objects as further along in their trajectory than seen by the eyes, giving us time to respond, according to research by Gerrit Maus, lead author of a paper published in Wednesday's issue of the journal Neuron.

This clever adjustment -- compensating for the sluggish route from the eyes to neural decision-making -- "is a sophisticated prediction mechanism," he said.

"As soon as the brain knows something is moving, it pushes the position of the object moving forward, so there's a more accurate measure of where this object actually is," said Maus.

This is useful in survival situations far more important than sports -- such as when we're crossing a street, in front of a speeding car.

Former Yankees catcher Yogi Berra pondered the mystery, once asking: "How can you think and hit at the same time?"

You can't, because there's not time for both.

"But you don't need to think about it, because the brain does it automatically," said Maus.

At the average major league speed of 90 mph, a baseball leaves the pitcher's hand and travels about 56 feet to home plate in only 0.4 seconds, or 400 milliseconds.

Tennis is even faster. Last May, courtside radar guns measured a serve by British player Samuel Groth at 163 mph.

In that split second, there's a lot of work for the body to do. Eyes must first find the ball. The sensory cells in the retina determine its speed and rush this information to the brain. Then the brain sends messages through the spinal cord that tell muscles in the arms and legs to respond.

"By time the brain receives the information, it's already out of date," said Maus.

The researchers said it can take one-tenth of a second for the brain to process what the eye sees. That means, for example, that by the time the brain "catches up" with incoming visual information, a fast-moving tennis or baseball would already have moved 10 to 15 feet closer than the image in the eye.

A region in the back of the brain, called area V5, computes information about motion and position -- and projects where it thinks the ball should be, rather than where the eyes saw it.

For the experiment, six volunteers had their brains scanned with a functional MRI as they viewed the "flash-drag effect," a two-part visual illusion in which we see brief flashes shifting in the direction of a motion.

The researchers found that the illusion -- flashes perceived in their predicted locations against a moving background and flashes actually shown in their predicted location against a still background -- created the same neural activity patterns in the V5 region of the brain.

In an earlier study, they stimulated this part of the brain to interfere with neural activity, and disrupted this visual position-shifting mechanism.

The finding could also help explain why altered trajectories can fool us -- such as tennis backspins or baseball pitches with so-called late break.

A clearer understanding of how the brain processes objects in motion can eventually help in diagnosing and treating myriad disorders, including those that impair motion perception, according to the UC Berkeley team. People who cannot perceive motion cannot predict locations of objects and therefore cannot perform tasks as simple as pouring a cup of coffee or crossing a road, researchers said.

"The brain doesn't work in real time," said Maus.

Contact Lisa M. Krieger at 650-492-4098.