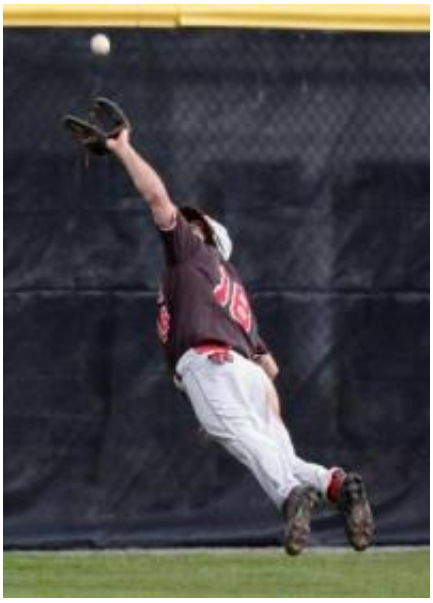
How does an outfielder know where to run for a fly ball?

January 21 2010



Researchers at Brown tested the three theories explaining how outfielders judge fly balls. It turns out to be a matter of optical acceleration cancellation. Credit: David Silverman/Brown University

(PhysOrg.com) -- Faced with a fly ball soaring deep into center field during the 1954 World Series, New York Giants center fielder Willie Mays turned his back on the ball, ran straight to the center field fence and caught the ball over his shoulder.

"The Catch" is among the best-known images in all of sports.

How did Mays do it? Did he predict where and when the ball was going to land just from seeing it hit? How does any outfielder actually catch a fly ball?

Brown University researchers have concluded that prediction has little to do with catching a fly ball. By using a virtual environment in which volunteers ran after computer-generated fly balls, researchers were able to confirm one of three major theories about how baseball players catch fly balls: It's a matter of optical acceleration cancellation.

Instead of predicting the ball's likely landing point, the outfielder's eyes continuously track the ball as its visual velocity increases or decreases, and the outfielder runs backward or forward to compensate. "The Catch" is famous precisely because fielders rarely turn their back on the ball. Mays may have added luck to the equation. Details are online at the *Journal of Vision*.

"All the fielders need to do is track this optical variable and it will lead them to a successful catch," said William H. Warren, professor of cognitive and linguistic sciences at Brown and the paper's senior author. "They don't have to do a lot of heavy computation in their heads to predict the landing point."

Warren collaborated on the paper with lead author Philip W. Fink, a former postdoctoral associate at Brown who is now lecturer in exercise and sport science at Massey University in New Zealand. Co-author Patrick S. Foo, another former postdoctoral associate, is now assistant professor of psychology at the University of North Carolina-Asheville.

Warren said that understanding how outfielders catch fly balls might help coaches advise ballplayers and teach children how to play baseball, but the significance of the finding goes well beyond baseball.

"This is a classic example of visual-motor control, because the limits of human ability are really being tested," Warren said. "If we can understand these key cases, it gives us some insight into how visual control works in more everyday situations."

The finding is contrary to currently popular models of visual-motor control that assume people have a model of the world and its physical laws in their heads, Warren said.

In conducting the research, Fink, Foo and Warren wanted to test three major theories of how an outfielder catches a fly ball:

- The mental model of trajectory. Outfielders rely on subconscious internal models of the physical world to calculate the ball's trajectory and predict its landing point.
- Linear optical trajectory. Outfielders run in such a way that their visual image of the ball appears to form a straight line.
- Optical acceleration cancellation. First published in 1968, the theory proposed that the outfielder tracks the elevation angle of the ball after it is hit. If the angle accelerates, the ball will land behind the ballplayer; if it decelerates, the ball will land in front. The fielder moves forward or backward to compensate.

Eight varsity baseball players and four varsity softball players took part in the study, fielding "virtual" fly balls in Brown's Virtual Environment Navigation Lab. Each wore a head-mounted display that allowed them to see the virtual ball as it was launched, and they ran freely in the 40-by-40-foot research space to make their virtual catches. Their movements were consistent with the optical acceleration cancellation theory.

Conducting the research virtually allowed Warren and the team to test the three theories by making the ball fly on a physically impossible trajectory. They then recorded the subjects' head and glove positions to figure out how they were trying to catch the ball.

While all three models can predict successful catches and similar running paths, the digitally altered or physically impossible trajectories included in this research show that baseball players continuously track the ball and run forward or backward to cancel optical acceleration. "Catching is clearly a perceptual motor skill that you have to learn," Warren said, "but it does raise interesting questions about why some people are so much better at it than others."

Warren said some individuals may have a greater sensitivity to visual acceleration or may use it to calibrate their movements more precisely.

More information: www.journalofvision.org

Provided by Brown University