Catching Fly Balls: A New Model Steps Up to the Plate

With the end of the baseball strike, fans will be spared the sight of replacement players bobbling balls and bungling plays. There is one area, however, in which even the replacement players could have done an acceptable job: catching routine flies to the outfield. In fact, even recreational players can chase down a lazy fly ball. How do players of average talent routinely manage to run to the right spot at the right time?

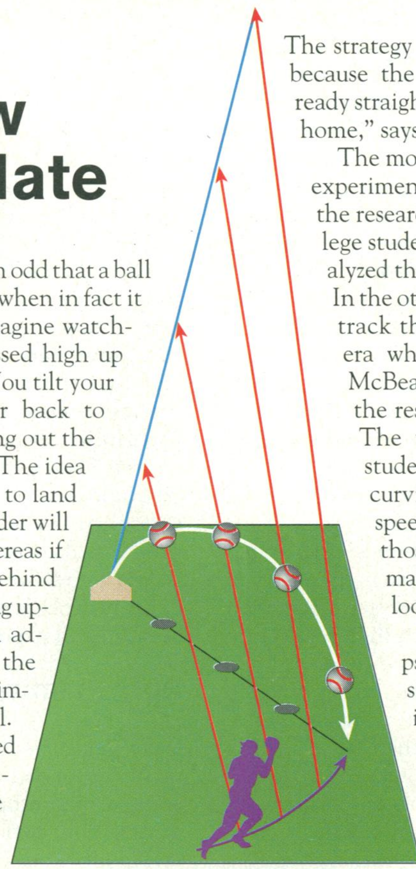
Like many skills, catching a fly ball is easier done than explained. But with the help of a mathematical model and some college students toting video cameras, psychologists Michael McBeath and Dennis Shaffer at Kent State University and Mary Kaiser at the National Aeronautics and Space Administration's (NASA's) Ames Research Center in Moffett Field, California, think they have uncovered the strategy every fielder uses without being aware of it. The key, they report on page 569 of this issue of *Science*, is to run so that the ball's trajectory looks straight. Do that—something that the human visual system is well equipped for—and you will end up in a spot where the ball will drop into your glove.

Joe Diestel, a mathematician and baseball enthusiast at Kent State, thinks the researchers have hit a home run. "It's a fascinating model, because it explains a number of lessons that you hear very early on if you're playing any kind of ball," he says. McBeath and his colleagues add that understanding the strategy might also turn out to be valuable in designing visual aids for, say, navigation in space.

In principle, there's no trick to tracking a fly ball. The ball's path across the sky contains more than enough information to guide you to the spot where it's going to land. A specially built robot could field balls by solving a relatively simple set of equations based on the observed curvature and acceleration. But outfielders running for a fly ball obviously don't have time for solving differential equations. Instead, they must have some rule-of-thumb strategy for interpreting the ball's path on the fly.

In 1968, Seville Chapman at Cornell Aeronautical Laboratory Inc. in Buffalo, New York, proposed that fielders head for the right spot by running along a path that cancels the apparent acceleration of the ball as gravity pulls it to Earth. In Chapman's model, an outfielder catches a fly ball hit directly at him by running forward or backward until the image of the ball is going straight up at a constant rate. (It may seem odd that a ball can appear to be going up when in fact it is falling to Earth, but imagine watching a ball that's been tossed high up and comes down at you: You tilt your head further and further back to keep the ball from escaping out the top of your field of view.) The idea is that if a ball is destined to land in front of him, the outfielder will notice it decelerating, whereas if it is destined to land behind him, he'll see it accelerating upward. Either way, he can adjust his position to cancel the acceleration and position himself directly under the ball.

Psychologists have raised doubts about this picture, however. They have pointed out that people's perception of acceleration is not good enough to account for their skill at shagging flies. Moreover, the acceleration model suggests that balls hit directly at an outfielder should be easier to catch than balls hit off to the side, because canceling the optical acceleration should be easiest for someone standing along the path of the ball. But experienced outfielders actually prefer to take a few steps to the side so they can get a "good look" at the ball, says Diestel, who coaches summer league baseball.



Eye on the ball. By running so that the ball seems to fly upward in a straight line, a fielder is guaranteed to catch it.

SOURCE: MCBEATH *ET AL.*

That's where McBeath's team takes the field. While he was pondering the optical acceleration model, McBeath recalls, a simpler strategy occurred to him: Run along a curving path, adjusting your speed and direction so that the apparent trajectory of the ball stays in a straight line (see figure). The strategy is as reliable as judging optical acceleration, says McBeath: "If you're running along a path that doesn't allow the ball to curve down, then in a sense you're guaranteed to catch it," because it always stays above you. And it may be more natural, curvature being something that the eye is good at perceiving. In fact, he adds, "that's a general approach for tracking and approaching things that's probably used by many organisms"—a possibility he and his colleagues say is supported by experiments with fish and houseflies.

Diestel points out that the psychologists' model can also explain why outfielders find balls hit straight at them difficult to catch: The strategy breaks down in that case because the optical trajectory is already straight. "Things like that strike home," says Diestel.

The model hit a home run in two experiments at Kent State. In one, the researchers videotaped two college students catching flies and analyzed the paths the students took. In the other, they had the students track the ball with a videocamera while running to catch it. McBeath and his colleagues say the results support their model: The videos showed that the students tended to run along curving paths, varying their speed along the way, and that those paths had the effect of making the ball's trajectory look straight.

James Dannemiller, a psychologist at the University of Wisconsin who has investigated aspects of optical acceleration, is intrigued by the new model but is not yet ready to rule it foul or fair. "There are a lot of different variables that you could conceivably use to get you to the right place [to catch a ball]," he notes. "It's very difficult to determine which variable or variables the runner is actually using." But he adds that "the beauty of all these models is that people are finally pointing to variables that are actually there in optical stimulation." The models, he says, aim to "demystify what seems like a mysterious process."

None of these models, however, will do much to improve baseball, even at the amateur level. "Most of the errors that people tend to make are not that they can't get to the right place, but that the ball bounces out of their mitt or they close their eyes," McBeath observes. But Kaiser notes that NASA, which sponsored her research, isn't particularly concerned with catching baseballs anyway. What the aeronautics crowd is rooting for is a better understanding of how people use visual information for navigation, Kaiser says: "The question is which sources [of data] seem to be the most useful and reliable for the human observer, and which ones do you need to preserve if you're creating a synthetic display [for example]?"

And on that kind of question, any help is welcome, even from amateur outfielders. After all, when you're trying to dock a multibillion-dollar spacecraft, you don't want to have to come back to the dugout and admit to the manager that you misjudged the angle.

–Barry Cipra