IT'S ALL ABOUT ANTICIPATION

Ryan Howard and Rafael Nadal don't have quicker reflexes than you do. They hit the fastest pitches and return the hardest serves because they can see the future

BY DAVID EPSTEIN

Barry Bonds went down on three pitches, didn't even swing. Albert Pujols and Mike Piazza couldn't make contact. Paul Lo Duca, Larry Walker, Richie Sexson, Dmitri Young: K, K, K, K. A-Rod took the wise course and decided not to even step into the box. The best any big leaguer fared against Jennie Finch, the 6' 1" former softball ace who took on baseball players in 2005 on Fox's *This Week in Baseball*, was Sean Casey's dink to the right side.

Coming from 43 feet away in the upper-60-mph range, Finch's heater takes about the same time to get to the plate as a mid-90s major league fastball. Nothing unusual for the world's greatest hitters in terms of speed. And yet big league players have a history of feckless whiffing, against underhand pitchers.

Beginning in the 1940s, softball pitcher Eddie Feigner and his three position players, known as The King and His Court, barnstormed the country and showed up baseball players by winning four against nine. In a 1964 exhibition at Dodger Stadium, Feigner—the Meadowlark Lemon of the team, hiding the ball and joking with the audience—struck out Willie Mays, Willie McCovey, Brooks Robinson, Maury Wills, Harmon Killebrew and Roberto Clemente . . . in a row.

Besides throwing between his legs or blindfolded, both of which he did with surgical accuracy, Feigner had another gambit: He usually steered clear of softball players. In fact he'd sooner face a Hall of Fame–bound baseball player than the local beer league boys. "There were other softball pitchers as good as Feigner," says Jerry Thomas, dean of the University of North Texas College of Education, who has studied expert athletes and played against Feigner in a game in 1958. "But he knew baseball players couldn't hit the softball. People assume it's easier to hit because it's bigger. But it comes from a different distance with a different motion. He would strike out professional baseball players from second base, but he usually avoided playing softball teams."

The reason baseball players can hit 100-mph fastballs but whiff at 70-mph softballs gets to the heart of what it takes to intercept a speeding projectile with a wooden stick. If hitting relied simply on human reaction speed, it would not be possible.

For the last three decades sports psychologists have been assembling a picture of how elite athletes hit 95-mph fastballs or return 150-mph tennis serves. The intuitive explanation is that the Ryan Howards and Rafael Nadals of the world simply have faster nervous systems—quicker reflexes, which give them more time to react to the ball. But it turns out that when elite hitters, from baseball and tennis to badminton to cricket, are hauled into the lab, their reaction speeds are no better than those of people chosen off the street.

In tests involving pressing a button in response to a flashing light, most subjects—athletes and nonathletes alike—take about 200 milliseconds, or a fifth of a second. (You can test yourself online at humanbenchmark.com) So, researchers conclude, a fifth of a second is about the bare minimum needed for the eye to take in information and convey it by electrical impulse to the brain, and for the brain to relay a message to the hands. "Once that pitch reaches the last 200 milliseconds," Thomas says, "you can't change your decision anymore. You're already swinging where you're swinging—and a lot can happen in the last 200 milliseconds of a pitch."

Two hundred milliseconds is almost half the entire flight time of a big league heater; the batter must start his swing before the ball is halfway to home plate. And given that the window for actually making solid contact with a fastball is about five milliseconds, or 1/200th of a second, it's a wonder that anyone ever hits it. In fact, the only way to accomplish it—the technique that separates the expert from the amateur—is to see the future.

Bruce Abernethy was an undergraduate at the University of Queensland in Australia and an avid cricket player in the late 1970s when he started wondering about the visual information employed by top batters. He began shooting cricket bowlers on Super 8 film and would then show test subjects the film but cut it off before the throw and have them try to predict where the ball was going. In the decades since, Abernethy, a professor in the School of Human Movement Studies at the University of Queensland, has become exceedingly sophisticated in his methods for so called "occlusion studies"—tests that block part of the

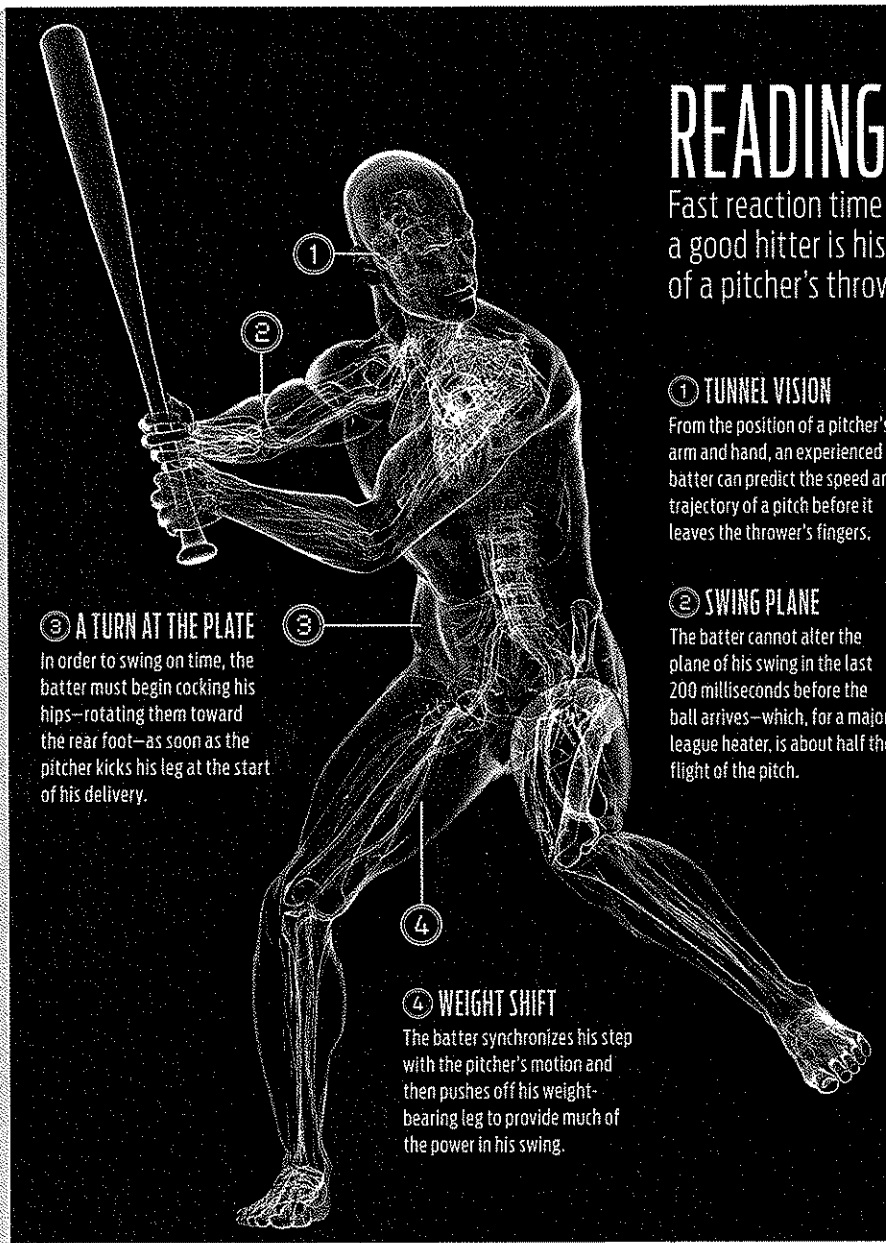
MYTH BUSTER

NO. 3: CORKED BATS HELP SLUGGERS

While hollowing out part of a bat's barrel and replacing it with cork lightens the bat, it also reduces the total mass, making for a less violent collision with the ball, which in turn will not fly as far. But for a hitter just trying to make contact, corking shifts the center of mass toward the handle, allowing him to start his swing later, get around quicker and make it easier to control the bat.

READING THE CUES

Fast reaction time helps, but what really makes a good hitter is his ability to process the nuances of a pitcher's throwing motion

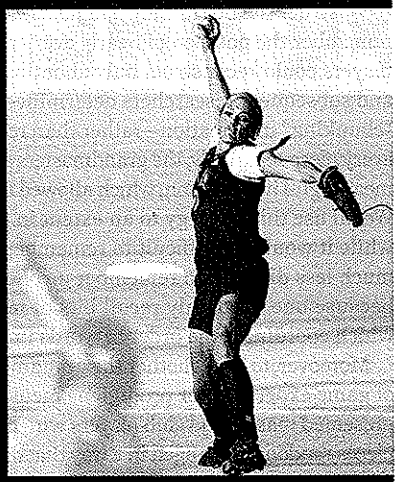


1 TUNNEL VISION
From the position of a pitcher's arm and hand, an experienced batter can predict the speed and trajectory of a pitch before it leaves the thrower's fingers.

2 SWING PLANE
The batter cannot alter the plane of his swing in the last 200 milliseconds before the ball arrives—which, for a major league heater, is about half the flight of the pitch.

3 A TURN AT THE PLATE
In order to swing on time, the batter must begin cocking his hips—rotating them toward the rear foot—as soon as the pitcher kicks his leg at the start of his delivery.

4 WEIGHT SHIFT
The batter synchronizes his step with the pitcher's motion and then pushes off his weight-bearing leg to provide much of the power in his swing.



UNTOUCHABLE
Major league sluggers haven't been able to hit Finch's softball pitches—not because she throws harder than the aces they face during the baseball season, but because they're not familiar enough with her moves to predict the flight of the ball.

CRYSTAL LOGHUDICE/US PRESSWIRE

thrower's or server's body, or that stop the motion before it's finished.

Abernethy has put special goggles on tennis players that black out their vision just before an opponent serves the ball. He has shown cricket batters video of bowlers with various parts of their bodies deleted, and he has had batters wear special contact lenses that blur their vision. The idea is to determine how expert athletes intercept projectiles and what information they need to do so.

Because top hitters react no faster, on average, than the general population, the only way they can hit the ball better is to anticipate where it's going long before it gets there. Compared with lower-level players, Abernethy found, pros can tell where the ball is going much more accurately, much earlier and with much less information. For instance, top tennis players can tell from the pre-serve movement of their opponent's body—sometimes just tiny shifts of the torso—whether a serve will be on their forehand or backhand. Average players, in contrast, must wait to see the motion of the racket, losing valuable time.

Abernethy has also found that when he deletes everything but the hand, wrist and elbow of a cricket bowler from a video, elite players in some cases still see enough to determine where the ball is headed. "There's significant information between the hand and arm, where they get cues for making judgments," Abernethy says. In badminton, if he edits out the forearm and the racket, top players are reduced nearly to novice level, an indication that seeing the lower arm is critical to decision making in that sport. And it doesn't even matter if the arm doesn't look like an arm. Top players still exhibited anticipatory prowess when Abernethy replaced human joints with points of light in digital simulations.

And yet, professional baseball players were unable to touch Finch or Feigner even without any perceptual impediments.

That's because they simply have not developed the mental data to allow them to anticipate such unfamiliar movements—a skill that comes only with years of exposure and practice.

Before occlusion studies shed light on perceptual expertise in sports (the first significant tests were performed by Canadian researcher Janet Starkes on volleyball players in 1975), studies of chess masters were beginning to illuminate the underlying processes. In famous experiments starting in the 1940s, Dutch psychologist and chess master Adriaan de Groot gave grandmasters and club chess players five seconds to look at chessboards with the pieces arranged in game scenarios. Then the arrangement was taken away, and De Groot had the players reconstruct the board they had just seen. Grandmasters could remember the position of nearly every piece, while decent club players could reconstruct only about half the board. De Groot and subsequent researchers determined that the masters were "chunking" information—rather than remember the position of every piece separately, the grandmasters grasped small chunks of meaningful information, which allowed them to place the pieces. We all use this strategy to an extent in daily life. For example, while it would be difficult to remember 15 random words, it's much less difficult to remember a coherent 15-word sentence because one need only recall bits of meaning and grammar, which coordinate the order of words in your head.

Moreover, to test whether the grandmasters' skill is the result of game experience or prodigious memory, psychologists have presented master and club players with chess boards containing pieces randomly arranged in a way that did not make sense in the context of a game. In that circumstance the experts' memories are no better than the club players'.

What major league players and pro tennis and cricket athletes seem to do is to synthesize and group information about the human body based on their playing experience. Give them unfamiliar data, such as Jennie Finch's underhand pitching motion, and the years they've spent taking mental pictures of a pitcher's motion and the rotation of the ball are less useful. The human chessboard becomes suddenly more random, and the players are left to react rather than to anticipate.

The same goes for quarterbacks. Peyton Manning would probably have trouble recalling the exact position of randomly distributed players in the Colts' locker room, but show him those players positioned on a football field, and he would be better at recalling the arrangement because each segment—the positioning of the defensive backs relative to his receivers, for example—has an underlying, unifying meaning for him. That's why crafty defensive coordinators attempt to disguise a defense: They try to forestall Manning's ability to predict the future using cues from patterns he's seen before.

Additionally, a quarterback, like a baseball batter, does not have time to consciously analyze everything he sees. Despite the fact that Manning has spent thousands of hours breaking down film, it's impossible for him to recall everything he's seen in the video room. Instead, just as Ryan Howard unconsciously marshals a lifetime of data on pitchers' body movements, Manning processes all that he knows about how defensive schemes react to various offensive formations. If Howard or Manning had to sort through what they had previously seen in order to

MAJOR LEAGUE VISION

Visual acuity tests demonstrate that big leaguers and Olympic softball players simply see better than the rest of us

A major league player may not have faster raw reaction times than you do, but he probably has better vision.

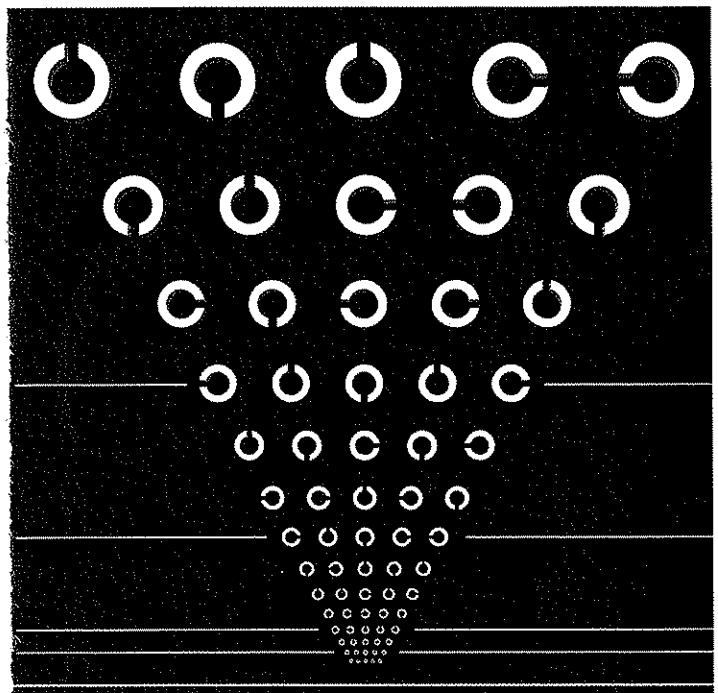
Because hitting hinges on anticipation, anything that gives a player an early clue as to where and how fast the ball will go should give him a better chance of intercepting it with his bat. That might be pitch count, which narrows the likely pitches to come (batters fare much better on 3-and-1 than on 0-and-2 pitches); the orientation of fielders; or the position of the catcher. It might also be information derived from the ball itself, such as its "flicker"—the indication of spin direction produced by the rotating seams. The earlier he or she can pick up such cues, the better his or her chance of connecting.

Between 1992 and '95 a group of ophthalmologists and other specialists tested the vision of 387 players in the Dodgers' organization. The first year the doctors used a commercially available visual acuity test that showed players Landolt rings—circles with a gap in one section that the viewer must pick out. This test gauged vision only up to 20–15, which means that the viewer can see something from 20 feet away that the average person would have to be within 15 feet to see. To the doctors' amazement, 81% of the pro players maxed out the test. "The next year we had to use different images," says Daniel M. Laby, an ophthalmologist who works with the Red Sox in spring training. "From 1993 on, our test went down to 20–8." That is the theoretical limit of human vision, given the morphology of rods and cones, the two types of photoreceptors in the human eye.

With the recalibrated test, the average visual acuity of pro baseball players was found to be about 20–13, and only a small number of players, usually pitchers, were worse than 20–20. About 2% of players achieved results better than 20–9, approaching the theoretical limit. "I can pretty comfortably say that in 20 years of caring for peoples' eyes, I've never seen someone outside pro athletics achieve that," Laby says. A study of U.S. Olympic athletes published in May found similar results among elite softball players, whose average visual acuity was approximately 20–11. The baseball players studied were also superior to the overall population—and big leaguers were better than minor leaguers—on an array of other tests, such as picking out figures that only slightly contrast with the background and perceiving fine variations in depth.

Many players seek to enhance their contrast sensitivity, at least in the field, with tinted sunglasses that help them pick out a white ball against white clouds, just as skiers wear tinted goggles that make the relief of a white hill jump out. Mark McGwire used custom-tinted contact lenses at the plate, though it's not clear how much they might have added to his 20–10 corrected vision.

Given the importance of picking up contrast and other visual cues, it could be that the seams of a professional softball—red on yellow as opposed to the red on white of a baseball—help explain why baseball players can't hit softball pitchers, and why even softball batters rarely hit the best softball pitchers. —D.E.



DODGERS' EYE EXAM This illustration simulates a test involving Landolt rings—each of which has a space in one side—in decreasing sizes. Two decades ago members of the L.A. organization were asked which side of each ring contained the gap, down to the smallest they could see. Eighty-one percent proved to have at least 20/15 vision, meaning they could see things 20 feet away that most people could see only at 15 feet.

make a decision, he would take too long and certainly fail. It has to be automatic.

Brain-imaging studies have shown that when people are first learning a skill such as driving a car, they engage the higher-conscious areas of the brain such as the cerebral cortex. But with practice, the skill becomes automated and moves to more primitive brain areas like the cerebellum. Thus experienced drivers can maneuver a car with far less active attention, at least until faced with unanticipated obstacles. And quarterbacks can choose where to throw while under pressure without consciously thinking back on every defensive arrangement they've ever seen.

Phillip L. Ackerman, a professor of psychology at Georgia Tech who studies skill acquisition, uses a military analogy to describe a quarterback's decision-making process: "It's an if-then task. If you recognize a certain pattern, you react to it. And you have to do it without thinking about it. It's like a soldier taking apart a weapon when it jams. You learn it to the level where you can do it without thinking, because people are shooting at you."

This science contradicts some of sports' hoariest beliefs. The exhortation of every Little League coach to "keep your eye on the ball"? Impossible. "If you monitor the eyes of batters, the gaze stops tracking the ball before they hit," Abernethy says. "You don't have a visual system fast enough to track the angular changes that occur over the last few meters of the flight." Nonetheless, he says, *keep your eye on the ball* is probably sound advice, because it keeps your head still and pointed in the right direction to gather the necessary information from the pitcher's body.

"The real advice would be, 'Watch the shoulder,' " Abernethy says, "but [even] that doesn't help. It actually makes [players] worse." That's because forcing an athlete to think consciously about an automated task destroys his ability to anticipate and puts him back in the realm of reaction.

Coaches who call timeouts to ice free throw shooters and field goal kickers are trying to exploit what researchers have codified: Break up the routine; get the player thinking. University of Chicago psychologist Sian Beilock, author of the book *Choke*, has demonstrated that, in golf, pressure-induced poor putting can sometimes be overcome with simple remedies such as singing to yourself or counting backward by threes. For automated tasks like putting or placekicking, mild distraction, rather than intense concentration, may be the best approach because it keeps the process out of the higher-conscious areas of the brain, where what Beilock calls "paralysis by analysis" takes root.

Another implication of studies of expert athletes is that pitching machines are probably rather useless for developing the most important skills involved in hitting. While they might be good for practicing mechanics or developing strength, they fall short in terms of sharpening the anticipation skills that are needed to hit live pitching. "The machine is completely predictable," Abernethy says, "which is the antithesis of the natural task."

This may also explain why a pitcher with a strange windup, like Hideo Nomo, could thrive in his rookie season (2.54 ERA) but never touch that performance in the years that followed. Hitters had gathered sufficient visual data on his motion. The importance of visual clues also explains why Yankees closer Mariano Rivera is nearly impossible to hit when he's on his game. Perry Husband, a longtime hitting coach in California who has studied millions of major league pitches, says videos show that Rivera's motion for his cutter and four-seam fastball are identical—as is the flight of the ball three quarters of the way to the plate (beyond the 200-millisecond line) before it breaks to one side or the other of the strike zone. "Everything he throws is lying to the hitter's eyes," Husband says.

And sometimes what the pitcher throws might lie to more than the hitter. Among Eddie Feigner's tricks was a pitch in which he would whirl his arm in several directions before throwing from behind his back. Or so it seemed. Feigner would actually throw the ball into his own glove. The catcher would then stand up as if having caught the ball and throw it to first as if there had been a strikeout.

Often an umpire would call the strike, perhaps not wanting to admit the embarrassment of losing sight of the ball. Then Feigner usually let the ump in on the joke, so the count could be corrected. But during a game in Canada once, Feigner didn't let on—because after the umpire called a strike, the batter argued vociferously that the pitch had been high. Based on the cues he picked up to anticipate Feigner's pitch, he may well have been right. □

MYTH BUSTER

NO. 4: OXYGEN MASKS AID RECOVERY

In a study, exhausted soccer players were given masks to breathe into. They received a placebo of normal air (about 20% oxygen) and then 100% oxygen (sideline masks deliver up to 50% oxygen). More oxygen didn't speed their recovery at all. Why? They already have as much oxygen in their blood as they can take, they're just not able to deliver it quickly enough to their cells.