Researchers studying Wimbledon games find humans are hard-wired to misread the true position of fast-moving objects, including tennis balls whizzing by at more than 100 mph.

UC Davis scientists have confirmed what tennis great John McEnroe so colorfully alleged on the court: Wimbledon referees make bad calls when judging balls hit close to the line.

It's not a matter of incompetence, as McEnroe frequently asserted. Rather, the human brain is hard-wired to misread the true position of fast-moving objects, including tennis balls whizzing by at more than 100 mph.
It takes about 100 milliseconds for the image of an object to travel from the retina and a little longer for the brain to become aware of it. The brain compensates for this delay by anticipating the object's location.

At the All England Lawn Tennis Club, the inevitable result is that referees sometimes misjudge whether a ball is in or out, according to a new study published in the journal *Current Biology*. David Whitney, a vision scientist at the UC Davis Center for Mind and Brain, analyzed 4,457 points from the 2007 Wimbledon championship and zeroed in on cases in which the ball was incorrectly called out, or close to the out-of-bounds line. Using slow-motion replays and Hawk-Eye, the computerized ball-tracking system, the researchers identified 83 erroneous calls.

Without any delay in the brain, the referees would be equally likely to misjudge whether a ball is in or out. Instead, the researchers found that 70 of the errors -- or 84% -- were called "out" but were actually in.

A follow-up analysis of the 2008 Wimbledon tournament determined that 69% of the bad calls were unfavorable to the same team in both years. "This is not a problem with referees," Whitney said. "This is a problem with human vision." Bad calls are probably evenly distributed between teams, limiting their effect. But even if the call doesn't affect the outcome of a match, it can still influence the players' psychology.

The researchers concluded that tennis players should focus on challenging calls that are out, since they are more likely to be vindicated by the computerized ball-tracking system. They also suggested that Hawk-Eye replace human judgment altogether.

Wimbledon spokesman Johnny Perkins said the tournament would consider such a change but that the entire sport embraced the idea, "and that would appear most unlikely."

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