Left or right? Early clues to soccer penalty kicks revealed

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In the split second before foot meets ball, a soccer player's body betrays whether a penalty kick will go left or right, according to recent research in cognitive science at Rensselaer Polytechnic Institute. Photo Credit: Rensselaer: Daria Robbins

(PhysOrg.com) -- In the split second before foot meets ball, a soccer player's body betrays whether a penalty kick will go left or right, according to recent research in cognitive science at Rensselaer Polytechnic Institute. The findings could explain how some top goalkeepers are able to head off a penalty kick, diving in the correct direction in advance of the kick. It could also point the way to changes in how players kick, and goalies react.

The research, performed by Rensselaer doctoral student Gabriel J. Diaz, employed motion capture technology and computer analysis to identify

five early indicators of the direction a ball would ultimately be kicked. Diaz said his research stemmed from an observation of real-world penalty kicks, in which players aim for the left or right side of the goal while hiding their choice from the goalkeeper.

"When a goalkeeper is in a penalty situation, they can't wait until the ball is in the air before choosing whether to jump left or right - a well-placed penalty kick will get past them," Diaz said. "As a consequence, you see goalkeepers jumping before the foot hits the ball. My question is: Are they making a choice better than chance (50/50), and if so, what kind of information might they be using to make their choice?"

Diaz tested 27 potential indicators of kick direction - 12 drawn from sports literature and 15 derived from a computer analysis of the kicks - and identified five as reliable indicators of the direction the ball will go.

In the second part of his work, Diaz also showed that four of the five early indicators he identified are used by people who are able to predict the direction of the kick before the foot strikes the ball.

Diaz used motion capture technology - cameras, sensors, and software - in Rensselaer Associate Professor Brett Fajen's Perception and Action (PandA) motion capture lab to record the movements of three college-level penalty kickers. The technology is similar to that used to create realistic movement in computer-generated graphics.

More than 40 sensors placed on 19 major joints of the body (and the ball) recorded the movements of the kickers as they stood behind the ball, took two steps, and kicked either to the left or of the right side of a goal. Diaz recorded 126 kicks, half to the left and half to the right.

Then he tested the data he collected against the suite of 27 potential indicators.

Twelve of the indicators - such as the angles of the kicking foot, kicking upper-leg, and kicking shank - were movements of a specific, or "local," area of the body highlighted by coaches and sports psychologists. Among them he found that two -- the angle at which the non-kicking foot is planted on the ground, and the angle of the hips as the kicking foot swings forward -are reliable indicators of kick direction.

The 15 indicators identified in a computer analysis of the kicks were so-called "distributed movements" - patterns of coordinated movement throughout the body. Three of the "distributed" movements proved to be reliable early indicators, none of which appears to have drawn previous attention in sports literature.

Emerging evidence in the study of motor control has pointed to a significant role for distributed movements, Diaz said. He described distributed movement as a combination of movements developed over many repeated attempts to perform a task, in this case kicking in a particular direction.

"When, for example, you shift the angle of your planted foot, perhaps in an attempt to hide the direction of the kick, you're changing your base of support. In order to maintain stability, maybe you have to do something else like move your arm. And it just happens naturally," Diaz said. "If this happens over and over again, over time your motor system may learn to move the arm at the same time as the foot. In this way the movement becomes one single distributed movement, rather than several sequential movements. A synergy is developed."

A distributed movement is complex, but, as Diaz's second experiment indicates, some people may be using it - however unconsciously - to inform their judgment as to which direction the ball will go.

In his second experiment, Diaz played an animation of the motion

capture data to a group of 31 subjects, and asked the subjects to pick which direction they thought the ball would go. In the animation, each body joint is represented by a dot, and movement of the body is easily recognizable as such. The animation runs from the standing-start until the foot reaches the ball, at which point the screen goes black and subjects pressed a button to the left or right of the screen, indicating which direction they thought the ball had gone.

Among his 31 subjects, all of whom were novices to the activity, 15 were not able to score above chance (50/50), even when given one-half second after the scene to ponder the outcome. Sixteen, however, did perform better than chance.

Diaz then looked for relationships between successful judgments on ball direction and each of the "local" and "distributed" movements he had tracked. His analysis revealed strong correlations between the two "local" and two of the three "distributed movements" that were reliable indicators of kick direction.

"The question is, knowing these potential sources of reliable information, what do people actually use?" Diaz said. "I found four reliable sources that were well correlated with subjects' judgments."

Another finding, he said, is that the 16 successful subjects waited longer than the 15 unsuccessful subjects to make their choices (if the half-second elapsed without a response from the subject, no result was entered).

"There is a clear relationship between response timing and performance," Diaz said.

Diaz said his findings have set the stage for further exploration. He would like to create a training regime to guide subjects' attention toward

more reliable indicators of kick direction. He also wants to know if professional goalkeepers would perform better than novices on the task.

Similar studies using video data of penalty kicks among professional Dutch goalkeepers showed that not all professional players are better than novice subjects, he said.

"Only a subset are better than average. I want to know - what is it that these successful experts are doing better than novices?"

Provided by Rensselaer Polytechnic Institute