Don't curse the referee for bad decisions – blame his eyes instead

Francisco Belda Maruenda

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CASTING aspersions on the refractive capability of a referee is a time-honoured tradition among football fans the world over.

Cries of "where's your white stick?" and "get yourself new glasses" are regularly hurled in the direction of the men in black whose unenviable task is to apply the rules of the beautiful game. Now a Spanish doctor claims to have shown that the insults contain some element of truth and that the demands of refereeing outstrip human physiology.

Francisco Belda Maruenda MD, a specialist in family medicine in Alquerias, Murcia, Spain, believes he has discovered why offside decisions in soccer matches are often so controversial.

Writing in the British Medical Journal, Dr Belda Maruenda noted that in order for the offside rule to be applied correctly referees and linesmen must keep at least five moving objects in their visual fields at the same time - two attacking players, the last two defenders and the ball. But the human eye and brain cannot process all the necessary information to do this, and then make an instant, correct decision.

"This is beyond the capacity of the human eye, which may explain why so many offside decisions are controversial," Dr Belda Maruenda said.

The offside rule, part of the laws since 1866 three years after the sport was first codified in 1863, underwent its last significant change in 1925 and is the most complicated of the 17 statutes that govern the game.

In essence it states that an attacking active player is offside "if he is nearer to his opponents' goal line than the second-last opponent" when the ball is passed to him by a teammate. The last opponent is considered to be the opposing goalkeeper.

In other words, there has to be at least one defender, as well as the goalkeeper, in front of the attacker at the moment that the ball is played forwards to him.

The law was introduced to stop teams leaving an attacker standing next to the goalkeeper, waiting for a pass, while the other 20 players were all up at the other end of the pitch.

Using a series of mathematical calculations, Dr. Belda Maruenda set out to show how the physiology of the eye is not equal to the task of correctly calling offside decisions in all given situations.

"The eyes move to focus on objects and maintain them within their visual field. In doing so, they perform saccadic movements, smooth pursuit movements, vergence movements, vestibular movements, and accommodation," said Dr Belda Maruenda.

To detect an offside position, the human eye must be capable of detecting at least five moving objects at the same time and determining their positions relative to each other. The fixation point would be the ball, and to focus on the relevant players the eye would need to perform a saccadic movement. The time that the eye needs to detect all the objects is the sum of the integration of the eye movements and the accommodation that it has to do.

By demonstrating the latency period for each of these visual functions plus the time needed for the movement itself and applying it to a typical match situation, Dr Belda Maruenda shows that the referee's visual system is not equal to the task of applying the offside rule in certain situations.

"If all the players are within the visual field of the referee or his assistants and there is no need for accommodation, the minimum time needed to detect the three players relevant to an offside position is 160 ms, because of the capacity of the central nervous system for parallel processing of different objects moving at the same time and the visual capacity to store and integrate," he said.

The key factor in applying this rule correctly is that the player in question must be in the offside position at the exact time when the ball is passed from a team mate, not when the player receives the ball or when the ball is en route between the players.

Football is a dynamic sport. If we assume that an average player runs at a speed of 7.14 m/s (equivalent to running 100 metres in 14 seconds) in 100 ms he will move by 71 cm. If he moves in a direction opposite to the defensive player, the relative change in position between the two will be even greater.

"By reviewing the physiology of the eye movements likely to be involved in assessing an offside position, I have shown that the relative position of four players and the ball cannot be assessed simultaneously by a referee, and unavoidable errors will be made in the attempt. The use of modern technology during games –– freeze frame television and frame by frame analysis – is advisable to limit these errors," he said.

The offside position. There is no defender apart from goalkeeper in front of attacker at the moment that the ball is played forwards to him.

Findings add to long running controversy

While the debate may seem trivial to some, the consequences of an error in World Cup, international or league matches can be catastrophic in what has become a multi-billion dollar industry.

"Competition in most leagues is fierce, and when referees make errors of judgement the consequences can be far reaching," said Dr Belda Maruenda. "Many rules in soccer are straightforward and are almost always applied correctly, but others are more prone to misjudgment. One of the most controversial rules to apply is that of offside."

Coincidentally, UEFA, European soccer's governing body, recently stated that it intended to start investigations to see whether new technology might help referees to make some decisions in the game.

Dr Belda Maruenda's article also sparked off a flurry of correspondence on the British Medical Journal's website, some humorous, some complimentary and some critical.

Two such contributors, Thomas Flynn MD and Alex Shortt MD, ophthalmologists at the Institute of Ophthalmology in London, believe that Dr Maruenda's conclusion is erroneous. They point out that the linesman does not need to focus on five separate objects simultaneously – impossible in any case – in order to apply the offside rule.

"In most cases the goalkeeper is so far away from the other players that it is easy to identify the second-last defender. Assuming the linesman stays in line with this player then he has to determine only two things simultaneously: firstly, the position of the foremost attacking player relative to the second last defender; and secondly, the timing of the pass."

Flynn and Shortt argue that based on the fact that the human eye has evolved to possess different types of visual acuity for different visual tasks, that it is indeed possible to perceive these two separate events simultaneously.

"By using central vision to discern the relative position of the foremost attacking player to the second last defender and peripheral vision to detect the change in velocity/direction of the ball at the moment it is passed, it is possible for the human eye to detect an offside position," they conclude.

Dr Belda Maruenda refuted these criticisms, maintaining that while several players may be inside the visual field, there is just one fixation point, and therefore the image of only one player in the fovea. Changing the fixation point to bring the image of other players to the fovea requires saccadic movements.

"Saying that there is no need of starting eye movements, not even accommodation, to detect an offside in football, is against the present knowledge about physiology of the oculomotor system and the central nervous system," he added.

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No offside, players in correct position.

100 ms later (players' velocity 7.14 m/s), Incorrect offside. And the eye not yet has been able to locate the correct geographic position of all the players, when his team mate sends him the ball.

Courtesy of Francisco Belda Maruenda