

AN OFFSIDE POSITION IN FOOTBALL CANNOT BE DETECTED IN ZERO MILLISECONDS

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Errors when judging an offside position in football are very frequent^{1,2}. In the last years, several scientific papers have tried to explain the causes for human errors^{1,2,3,4,5,6,7}. When a referee or an assistant referee misjudges an offside position, it is thought to be caused by a human error. A human error means to carry out incorrectly an action we are physiologically qualified for. The hypothesis to be studied in this paper is if when judging an offside position it is possible to attribute errors to humans or to the fact that human physiology and the technical media are not capable of detecting an offside position. The offside rule⁸ has to be applied in real time, in zero milliseconds, in the precise moment when the ball is being passed, never 1 millisecond or even 1 millionth of a second later. This paper shows that the human being and the technological media are both physically and technically incapable of detecting an offside position in real time, in zero milliseconds. The results of this study show that when the ball is passed, the human eye^{9,10} and brain¹¹ and the technological media¹² need some time to locate the at least four players¹³ who intervene in an offside position. When those players are located, time has passed and they are never in the original position, when the ball was passed. Football players are trained for speed and acceleration to change their geographical position in the field when the ball is passed. Therefore, we cannot refer to a human error when an offside position is misjudged. The human being and the technological media will never be capable of detecting an offside position in real time, in zero milliseconds. The key of the offside position is a physical problem: time. The IFAB must abolish the offside rule.

The offside rule in football is one of the most controversial during football matches. Errors when judging an offside position are very frequent^{1,2} and they are always attributed to human causes. In the last years, several scientific papers^{1,2,3,4,5,6,7} have contributed in a very important way to understand why these errors happen. The human error has been related to optical errors based on the incorrect angle of view¹, the flash-lag effect³

and eye movements¹³. A human error means to carry out incorrectly an action we are physiologically qualified for. The problem is to find if the error has a human origin or not.

However, the solution for this problem is a very simple one. The easiest thing is to propose a hypothesis to see if the problem has a physiological origin, if it is located in the eye and in the brain, or if it is just a simple physics problem. We must take into account that the result of a football match may change if an offside position is misjudged. And this is related to economic effects valued in hundreds of millions of Euros: football pools, advertising, the players' and teams' economic value, etc.

The most important starting point is to understand what the offside position rule⁸ demands. This rule requires the offside position to be marked when the ball is passed, in zero milliseconds; never 1 millisecond or one millionth of a second after. This rule requires knowing the exact geographical position of the players who take part in the offside position when the ball is being passed. Besides, it has to be decided if the player who is going to receive the ball takes part in the move in an active way. The elements in an offside position are the ball^{8,13} (origin of the geographical horizontal line which delimits the offside position, because behind this line an offside position can never take place) and a minimum number of 4 players^{8,13} (2 of the attacking team and the last 2 players of the defending team), although in most moves, there intervene more players. If the human eye and brain and the technological media cannot detect an offside position in zero milliseconds, it is obvious to deduce that they are all physiologically and technically incapable of detecting an offside position in real time, because the players are very fast (the players have speed and acceleration) and they accelerate to change their geographical position in the pitch so that they cannot be detected when the ball is passed.

When the ball is passed, the physiological answer of the human body is the following one: the ocular fixation movements^{10,14} (microsaccadic, tremor and drift) detect the visual perception of the exact moment when the ball is being passed and this signal starts all the oculoneuronal process to detect if there is any player in an offside position (but the ocular fixation movements need time to be carried out). This signal is sent to the brain via the optic nerve (which also needs time). The brain receives all the information^{10,14,15}, stores it¹¹, processes it^{10,16,17} and sends an answer so that the oculomotor system is prepared to perform the necessary eye movements to detect all the players who take part in an offside position (this process takes time). The answer of the brain goes back to the eye through the oculomotor nerves (it takes time). Several saccadic¹³ and ocular

fixation movements¹⁰ are performed to locate all the exact geographical location of the players who can take part in an offside position (this is the process which takes the longest). This information of the visual field is sent back to the brain through the optical nerve (it takes time). With all the information, the brain decides if a player is in an offside position or not (it takes time) and it sends a motor signal (the assistant referee raises the flag, the referee blows the whistle) in case there is an offside position (this process also takes time).

These eye movements are extremely brief¹⁶, as well as the time the brain needs to process the information. The duration of ocular fixation¹⁶ takes between 30 and 40 milliseconds. Saccadic latency⁹ require from 80 to 135 milliseconds and duration of the saccadic movement^{18,19} takes between 30 and 100 milliseconds.

Some assistant referees use a technique to save time. They try to have in their visual field all the players who are likely to take part in an offside position and they just pay attention to the sound of the ball when it is passed. But the sound signal also needs time to be transmitted.

Previous studies have shown that when the ball is passed, the most common errors happen when the players (the forward player and the defender) run in opposite directions⁷, the defender towards the centre of the pitch and the forward towards the contrary pitch. Football players are trained in speed and acceleration to change the relative positions in the football field. The time the eye and the human brain need, is the moment the players use to exchange their relative positions in the football field, so that they cannot be detected in the exact geographical position they had when the ball was passed.

A similar process takes place with technological media. In the precise moment when the ball is passed, any technological media has to send a laser, electrical, electronic or radio frequency signal to the CPU of a PC¹². But this process needs time¹², even if it is one millionth of a second. In order to save time, other devices could send at the same time a signal to the CPU with the exact geographical location of the players who can take part in an offside position. Technological media could receive these signals simultaneously, but the human eye is not physiologically capable to carry out that function. The CPU receives, stores, processes, interprets and in case there is an offside position, it sends an acoustic or visual signal (but this process also takes time).

The human eye and brain and the technological media cannot detect an offside position in zero milliseconds, in real time. The key of the offside position is a physical problem: time.

We are witnessing the most massively known error in the history of humankind. Since the 19th century (the offside rule was introduced in 1866) thousands of millions of people thought, and they still think they can perceive and judge an offside position in real time, in zero milliseconds. The IFAB is facing a difficult problem: it has to abolish the offside rule.

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