

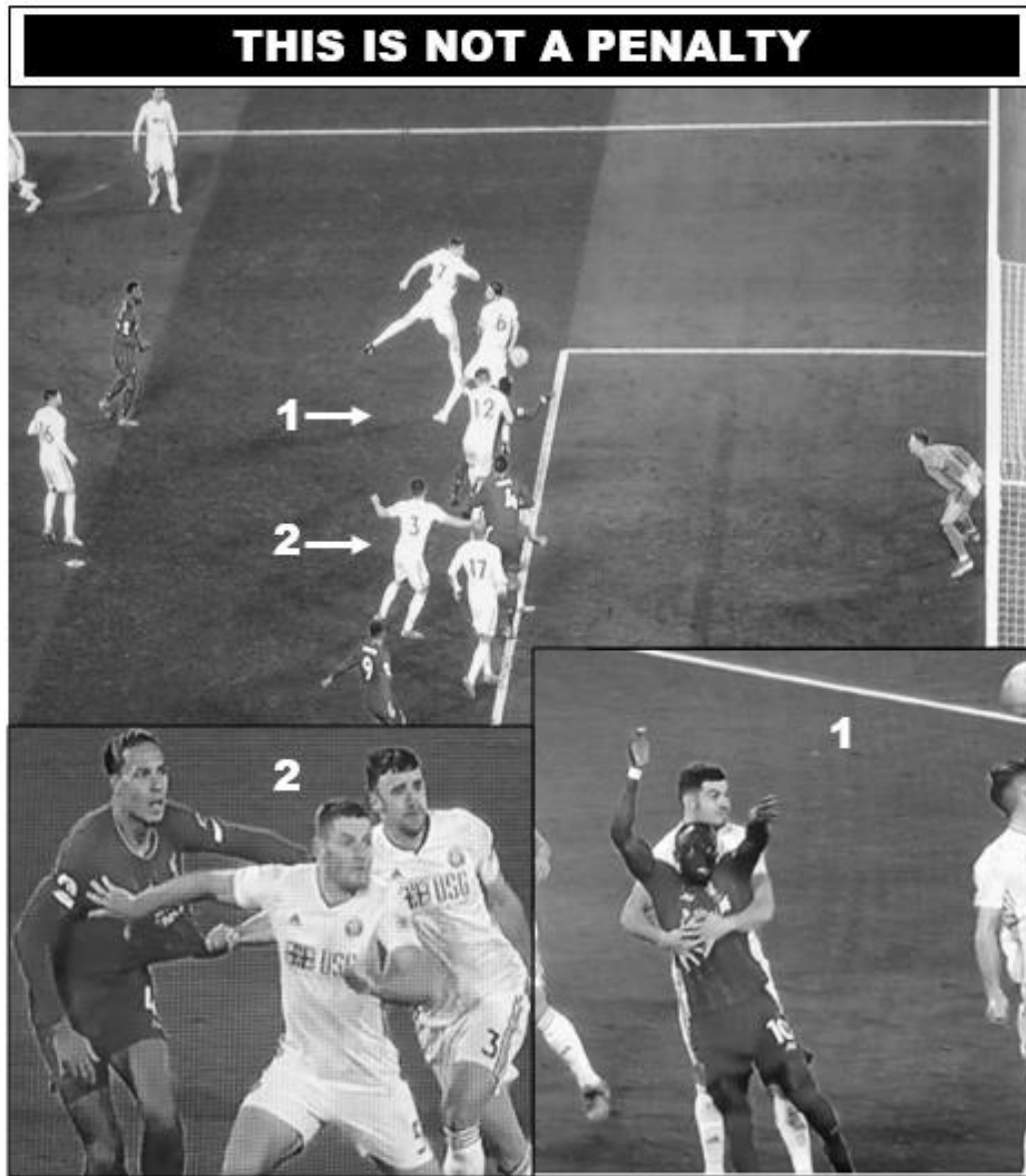
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This is not a penalty! What's gone wrong with technology and football in the age of VAR?

Harry Collins



Liverpool vs Sheffield United 2 Jan 2019, 49 minutes and 16 seconds into game, Liverpool in dark strip. Free kick from left wing with ball coming in rapidly from top of frame; both potential scorers appear to be illegally hampered, as shown in replay from behind the goal (insets). But referee plays on and Video Assistant Referee (VAR) does not comment. Commentator: 'Another one that will have everyone scratching their heads, Steve, it looked clear and obvious to me'. Steve McManaman makes comments to the effect that he is baffled [but since he is an ex-Liverpool player he may be thought to be biased] Commentator: 'I actually think that's one of the situations where a referee ... would appreciate some help, because there are situations where you can't see everything in the penalty area for a set piece. Who am I to debate VAR?' McManaman makes remarks to the effect that this is one of the reasons people are so frustrated at the whole VAR business at the moment.

This is not a penalty! What's gone wrong with technology and football in the age of VAR?

Harry Collins¹

In a book published in 2016, I and co-authors argued that the availability of slow-motion replays had revealed, to television viewers, the occasional striking injustice in refereeing decisions; we argued that these replays should be made available to match officials so that justice could be seen to be done.² We also showed that these injustices added up to make significant differences to teams' final positions in the UK Premier League. A different argument made in earlier papers was that refereeing was a matter of justice not an, illusory, exact accuracy: in 2008 we showed that ball-trackers could not be as accurate as they were said to be and in 2010(a), I analysed the referee's role in terms of justice and authority.

In the UK Premiership Football Season of 2019-2020, the Video Assistant Referee (VAR) has been introduced but, at the time of writing, only half-way through its first season, it is widely agreed that something has gone badly wrong. An example of the problem is shown in the opening figure and its caption. Here I want to try to explain why things have gone so wrong and link the problem to our earlier analyses of the referee's role and the technology of sport officiating; I want to point, again, to the problem of error

¹ I am grateful to Robert Evans, Trevor Pinch and Wiebe Bijker for careful readings of an earlier draft of this paper. Their wise comments led to many extensive and significant changes. Nevertheless, all misspeaks and infranities remain entirely my responsibility.

² See Appendix for discussion of possible pro-Liverpool bias in this paper.

and uncover some potential new errors in certain supposedly accurate technology; and I want to suggest that these problems are symptoms of much wider tensions in society, to do with scientific versus other values on the one hand, and expert judgement versus rule-following on the other, with consequences that reach far beyond sport.

Bill Shankly, the charismatic football manager, said: ‘Some people think football is a matter of life and death. I assure you, it's much more serious than that.’ In some ways he was right. Football and other sports are more than entertainment, they are major institutions in our societies and a society is made up of its institutions; the culture that makes a society is reflected in the culture of its institutions and the culture of its institutions continually re-creates the culture of the society. Thus Andrew Breitbart, the founder of ‘Breitbart News’, an important influence in the growth of populist politics with its championing of alternative truths and attacks on expertise, claimed that ‘politics is downstream of culture’. By this he meant that controlling and owning the means of cultural production was more influential than the formal institutional power of politics. Elsewhere, colleagues and I have argued that science is an important institution in our society because it can offer leadership in the meaning of integrity and challenge political power and that is why expertise is attacked by populist leaders.³ Sport is also a means of cultural production in respect of what is fair and what is not, but one with even more power to show us how to live because its audience is incomparably greater and more committed than the audience for science. The boycotts of South African sport in the

³ Collins and Evans, 2017a, ‘*Why Democracies Need Science*’; Collins et al, 2019, ‘*Experts and the Will of the People: Society, Populism and Science*’.

1960s onward helped to end apartheid and, in cricket-playing countries, the expression ‘it’s not cricket’ implies that cricket represents a standard of fairness and honesty. It is because sport is such a central institution in societies that we should not allow it to set standards of decision-making without them being open to scrutiny. Even though in tennis, a line-judging mechanism that has unknown errors where close calls are concerned, is now accepted as the *de-facto* standard, and even though, as I will argue, the same applies to ‘goal-line technology’, in accepting them we are setting standards about how facts are to be made in our world and, to those who value democracy, they are the wrong standards.

In a previous paper, it was argued that technological sport officiating aids should be as simple as possible so as to involve as little ‘intermediation’, or as much ‘directness’, between the action and the viewer as possible.⁴ The possibilities were divided into five classes as follows:

Level of indirectness	1	2	3	4	5
Examples	Bails Golf-cup High-jump bar	Photo-finish	TV-replay	<i>Manipulated</i> TV-replay Hot-Spot Snicko	Reconstructed-track devices

Table 1: Classification of Capture-devices [Originally Table 16.1 in Collins and Evans, 2017b]

⁴ Collins and Evans, 2017b

I now want to refine the argument, add some new information about some of the technologies and their use and reception, and set the entire approach in larger contexts, one of which is the philosophy and sociology of rule-following versus judgement.

It has to be said that the particular way VAR has been implemented in England is encouraging and amplifying all the problems that will be discussed here. In some cases, but not others, the distinction being somewhat mysterious to the regular football fan, for every football ground across the country, an on-field referee's decision is referred for checking to a body of technically equipped experts at a business zone called 'Stockley Park', about 2.5 miles north of Heathrow airport. The experts deliberate, sometimes in silence, and sometimes relaying some of their deliberations to the TV viewer and on-field referee, and sometimes return a conclusion to the referee's earpiece or sometimes simply make no intervention, allowing the game to continue. At the side of every football pitch is a small TV screen dedicated to VAR and the referee may consult it if desired so as to make the final decision about whether to accept Stockley Park's conclusions. In other countries referees continually consult such a screen and make the final decision but in England and Wales, this possibility had been used only once up to the beginning of January, 2020.⁵ In short, the set-up of VAR encourages technological solutions by distant authorities acting in sometimes mysterious ways that exclude the players and live crowds, home TV viewers having slightly better access to what is going on. The VAR authorities' attempts to explain their decisions are well-meant but unaccountable and

⁵ From the middle of January onwards, UK referees are being advised to make more use of the pitch-side monitor.

referees seem happy to relinquish their authority to these powers. This is changing the culture of football refereeing, making it more ‘technocratic’, and it is this change of culture that, it will be argued, is the underlying context for the discontent and a partial explanation for some of the bizarre happenings.

An example of the force of the technocratic culture that I will spend some time on is the claim that a rule that is described in terms of an exact binary distinction (for instance, the difference between ‘onside’ and ‘offside’ in football), can only be implemented in a binary way, whereas it will be argued here that it is better to implement it as a human judgement about the distinction rather than seek exact objectivity through measurement. So long as the viewer, especially the TV viewer, does not feel they could easily have done better themselves, the judgement does not have to be exact for decision-making justice to be seen to be done. To make marginal judgements even less contestable, I will suggest (along with many others) that there should be a ‘benefit of the doubt’ rule where appropriate – such as in offside in football. Most experts on football would say that the benefit of any doubt should be in favour of the attacking team since everyone seems to agree that more goals lead to more pleasing games. Benefit of the doubt might include some element of whether there was any advantage gained by the possible offside. Instead, as things stand, we have some bizarre decisions, some decisions that crowds and officials are satisfied with, but are spurious – a kind of ‘show trial’ has been acted out with very few people understanding that it is a show trial – and, frequently, the decision-making takes long enough to annoy everyone, destroy the rhythm of the game and destroy the passion and tension. Nearly all these problems could be solved by going back to simple TV replays as the technological aid, and abandoning much of the more complex

and indirect technology, handing authority back to referees, and changing refereeing culture back to the much less technocratic thing it has always been.

The offside decision in football

The way new officiating technologies in sport are received and understood by commentators and the public is a crucial question for the overall argument presented here. Offside is the first example we will examine. The discontent with the way offside is handled by VAR is swelling match-by-match and only half-way through the football season, giving rise to calls for the technology to be abandoned.

In football, play is stopped or a goal disallowed if the ‘offside’ rule has been violated. To be offside it to be nearer to the opposition goal than every player but one – usually the goal keeper – when the attacking team has the ball. But to *violate the offside rule*, the offside player must be ‘interfering with play’, for instance, obstructing the view of a defender or causing a defender to be unsure about which way to run during the course of an attack. The question of offside frequently arises when an attacking player passes the ball forward to another who is considered offside at the moment the ball is passed.

The offside rule prevents the play being compressed into the narrow region just in front of the goal with attackers waiting there (‘hanging about’ there – known as ‘goal-hanging’) to have the ball passed to them, and defenders having to stay well-back near their goal to prepare for such eventualities. If, given the offside rule, a player does receive the ball in an offside position, or others in offside positions are interfering with play, he or she would find it easier to run forward and score a goal than from an onside

position, thus gaining an unfair advantage. This is how Wikipedia describes the problem for the player receiving the pass:

An attacker who is able to receive the ball behind the opposition defenders is often in a good position to score. The offside rule limits attackers' ability to do this, requiring that they be onside when the ball is played forward. Though restricted, well-timed passes and fast running allow an attacker to move into such a situation ***after the ball is kicked forward*** without committing the offence. Officiating decisions regarding offside, which can often be a matter of only centimeters or inches, can be critical in games, as they may determine whether a promising attack can continue, or even if a goal is allowed to stand. [https://en.wikipedia.org/wiki/Offside_\(association_football\)](https://en.wikipedia.org/wiki/Offside_(association_football)) (emphasis added)

When an attacking player times the run perfectly, and arrives at the optimum point just at the moment the ball is kicked forward, the player is said to have ‘avoided the offside trap’ and this can be very dangerous for the defending side.

In the case of offside, the relationship between two things that happen at the same time – the pass and the position of the relevant player/s at the moment of the pass – has to be judged, but these two things happen at a distance from each other, a considerable distance where the forward pass is a long one. That is one reason why offside can be hard to judge in real time. Now that VAR is being used, wise referees allow play to unfold for a while, perhaps until a goal is scored, and only then look back to see if an offside offense was committed in the build up to the goal and whether, in consequence, the goal should

be disallowed. New technologies have been introduced with VAR to try increase the accuracy of the retrospective decision.

Many sports watchers think something has gone wrong in the case of the offside technology. I say this as someone deeply embedded in the culture of watching football and cricket on TV – a participant in the culture of televised sport – and familiar with the kind of remarks that the commentators on sports programs make and the discussions that I have with friends, colleagues, and family, about these things – I ‘speak the language’ of TV football.⁶ VAR offside decisions are criticised for delaying the game for far too long, for being made obscurely by unseen persons in a remote location, for failing to do what VAR was promised to do –address only clear and glaring refereeing errors – and, most subtle of all, for attempting to achieve *too much accuracy*! ‘Too much accuracy’ is the most interesting and hardest criticism to try to explain in philosophical terms, especially as it does not seem to apply to many other sport-decision aids that aim for exactness.

⁶ For an argument for just how strong evidence garnered from immersion in general discussion can be, see Collins’s, 2019b, *Method and Meaning of Sociology*. That book and this paper is written in the spirit of Wittgenstein’s later philosophy and Winch’s 1958 book, *The Idea of a Social Science*, which argue that the meanings of terms are their use and which, therefore, allow no distinction between philosophy and certain kinds of sociology. See also Bloor, 1983 ‘*Wittgenstein: A social theory of knowledge*’.



Figure 1: ‘Offside’ – Aston Villa vs Liverpool 2nd November 2019; the right shoulder of the attacking Liverpool player, Roberto Firmino, in white, is adjudged to be further forward than the defending player’s knee and the goal Firmino went on to score was disallowed on grounds of ‘offside’.

In the case of offside, VAR shows a TV replay of the frame when the pass was made with a virtual line drawn across the pitch level with the defender closest to the goal being attacked. The question is settled by looking to see if any attacking players are beyond this line and deciding whether they are interfering with play. More exactness is provided by dropping virtual lines vertically from the most forward part of the relevant player’s bodies (hands and arms don’t count) to the virtual line across the pitch – see Figures 1 and 2.

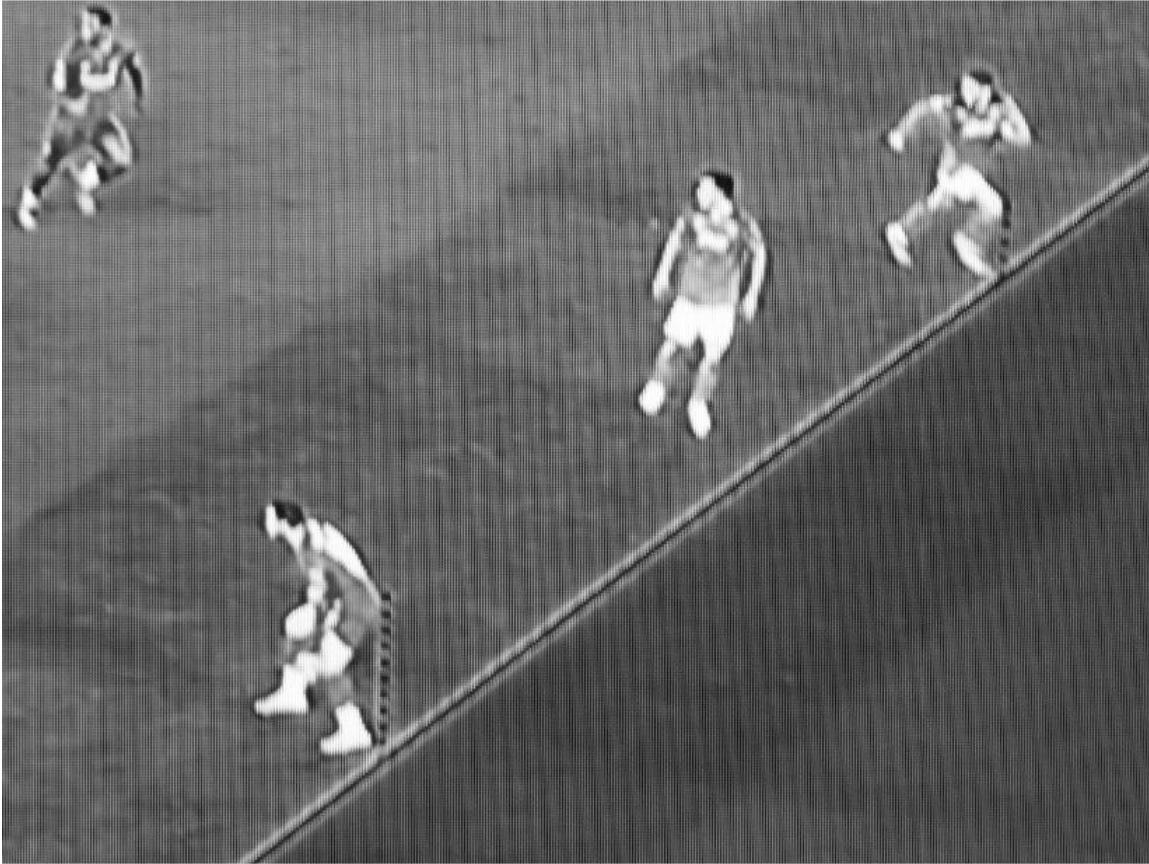


Figure 2: ‘Onside’ – Liverpool vs. Napoli, 27th November, 2019; the attacking player’s knee is adjudged to be no further forward than the defending player’s backside. The attacking player went on to score a goal.

What is missing from the offside debate?

What appears to be missing from the debate about offside, at least as far as my own and my friends’ and colleagues’ watching of televised football and football commentary is concerned, is any discussion about how accurate the judgement is – on the contrary the problem appears to be only that it is too accurate. As a result, I spent several days trying to work out how accurate it could be and coming to a startling conclusion: though claiming to make millimetre judgements in the case of offside, these could be subject to errors in the region of a foot (25 cm). While the lining-up of the players in a single frame can be done without much error, the choice of the frame that was to be analysed was subject to two kinds of errors: one that seems impossible to avoid emerges from the

fact that the exact timing of the correct frame is random to within a frame interval.

Suppose the camera is running at 50 frames per second and it is possible to choose the frame when the passing player first touches the ball when making the pass: the exact timing of that frame depends on the exact moment, within a 50th of a second, when the camera started to roll. A fast running footballer can run a foot or more in a 50th of a second. Only then did I discover that this fact was already in the public domain but it was simply not being discussed. Of course, there is potentially still greater error if it is less than clear which is the correct frame to analyse.



Figure 3: On-field decision ‘offside’ – Norwich vs Crystal Palace 1st January 2019; the pass is made by the player in white, arrowed, and the goal scored by player numbered 21 who looks clearly offside.

One can get a sense of the problem in Figures 3 and 4, which show stills from a domestic TV set covering the VAR intervention reversing the referee's 'offside' decision in respect of the 84th minute goal scored by Crystal Palace in their game against Norwich on 1st January, 2019. In this case, all the commentators were pretty sure that it was 'offside' and were sure that the referee was right.

Figure 4 shows two sequential shots of the same situation seen from the angle used by VAR. These are shots taken from VAR's replay but the domestic television, or it may be the record and playback mechanism deployed by the television, runs at 25 frames per second, so these stills are one 25th of a second apart whereas the stills examined by VAR may be half as far apart or less.⁷ Nevertheless, the problem is well-illustrated by these shots.

⁷ The technique, for those who want to check this kind of result for themselves, rendering these claims 'transparent', is to replay the recorded match broadcast, pause just before the appropriate place, and then press the fast-forward button repeatedly while paused. This, once it settles down, moves the recording along a frame at a time. By co-ordinating with the match-time displayed on the screen one can verify that 25 presses are needed/frames are displayed, in the interval taken for the displayed time to advance by a second.

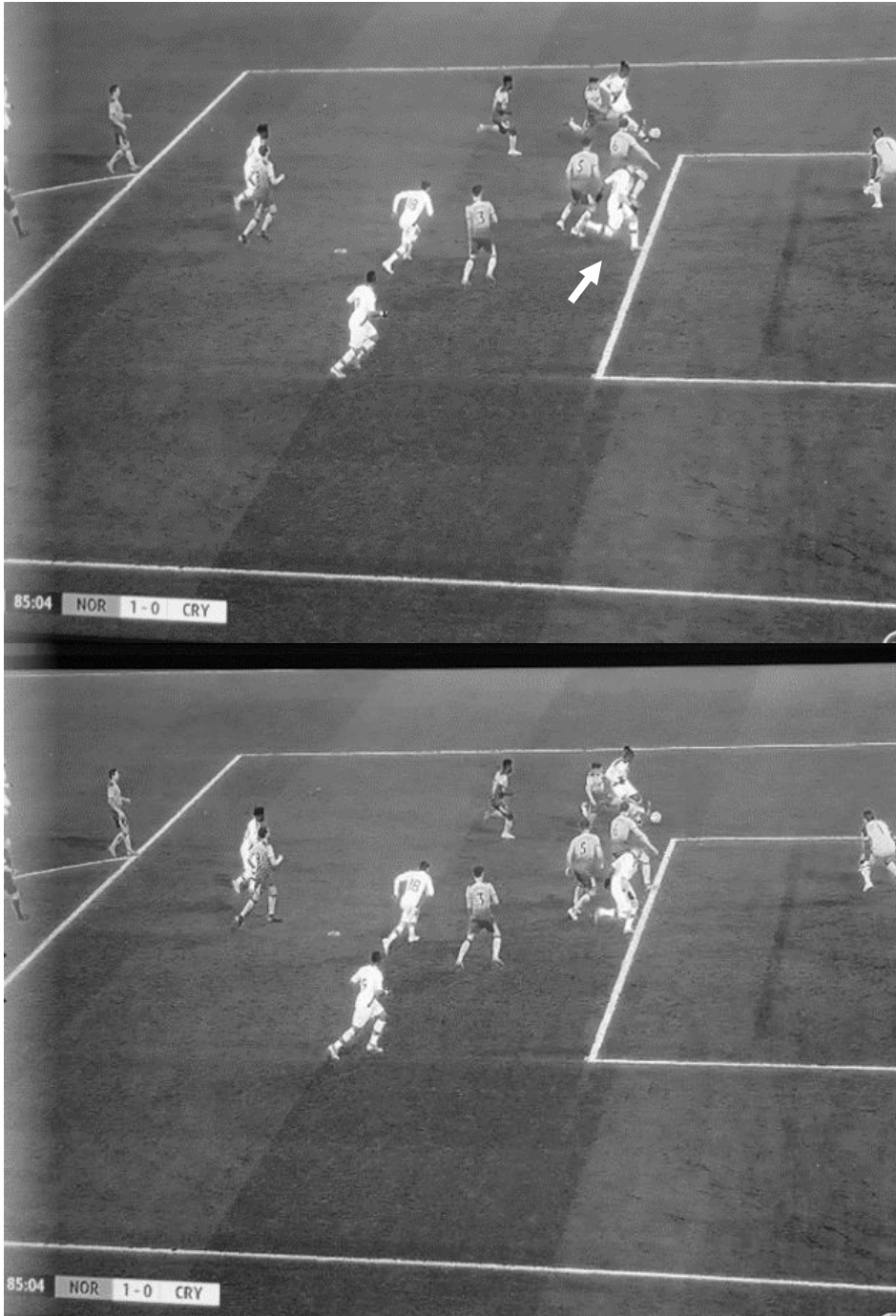


Figure 4: Off-field decision ‘onside’ – Norwich vs Crystal Palace 1st January 2019; the arrowed player is clearly offside in the first frame but VAR consider them to be onside in the second, preferred, frame.

In the first shot the attacking player is clearly offside and one 25th of a second later, in the second shot, the situation has become debatable, but was considered to be ‘onside’ by the remote VAR authorities explaining their decision by using their technology for

examination of a single frame. VAR will have access to one or two intervening frames but, as explained above, the random fraction of a second which any frame captures is arbitrary within a frame interval and is likely to mean that errors swamp the fine margins used by VAR to make these judgements. As far as I and my colleagues could see, none of the TV commentators they listened to, nor any of the members of their sport-fan communities, were aware of these possible errors – they certainly were not mentioning them – though they were very unhappy with the way VAR was reversing referee’s decisions by making millimetre decisions.

Because no-one else was mentioning them I initially assumed that I had ‘discovered’ the problem for the first time but a brief check on a web-browser would have told me that this argument and the associated calculations were already available in the public domain, if not availed of. For example, My calculation was repeated with some of my assumptions resolved <https://www.sportbible.com/football/news-calculations-show-how-var-is-not-suited-for-tight-offside-calls-20190922> giving a calculated error of around 7 inches. A piece in the *Daily Mail* online of 17 August, 2019, referring to the opening game of the Premiership season, presents the calculation and explanation of the error under the headline⁸:

⁸ <https://www.dailymail.co.uk/sport/football/article-7367673/THE-GREAT-VAR-DEBATE-Tech-said-Sterling-2-4cm-offside-allowed-13cm-margin-error.html>

THE GREAT VAR DEBATE: Technology is not yet advanced enough and said Raheem Sterling was 2.4cm offside... but allowed for a 13cm margin for error in making the decision

These various articles suggest that unless things have changed markedly, and I cannot find any mention of such a change, the Premier League is aware of the potential and actual huge inaccuracies, and may even be aware of how they vary from situation to situation, but VAR still uses the technology without mentioning the problem. An article can be found on the web in which the Premier League authorities explained how they draw the horizontal and vertical lines used to determine the exact question of offside at <https://www.premierleague.com/news/1488423> (last accessed 26 Dec 2019). They stress these lines are a single pixel thick and they also say that broadcast cameras, running at 50 frames per second, ‘can be’ used to determine the relationship of the passing players foot and the ball (the frame should show the moment when the foot first touches the ball). The potential error in this choice is not discussed in their explanatory piece, however. Why don’t the Premier League authorities make sure that VAR includes in its graphics the error associated with its offside decisions? Why does it continue to allow the public to think that, whether the public approve of it or not, VAR is truly making accurate determinations of the positions of players?

This is hard to explain though consistent with the attitude encountered when, in the 2000s, my colleague and I tried to discover information about how the Hawk-Eye

technology works – we were told that this was commercially sensitive information and at one point we were threatened with legal action if we continued our analysis.⁹

It is worth noting that, according to the *Daily Mail*, among the people who are included in those who think the technology is completely accurate is Pep Guardiola, the manager of Manchester City, the most successful English football club of recent seasons, whose player, Raheem Sterling, was the subject of the bizarre ruling, described in the *Daily Mail* piece. Guardiola is quoted as follows:

‘Maybe the intensity and passion will leave,’ said Pep Guardiola. ‘Hopefully, it doesn’t make mistake. If it’s offside, it’s offside.’

The ‘*Mail*’ goes on to remark, with irony:

Even Pep can rest a little easier knowing the decision was definitely, infallibly correct.

It is also worth noting that the Norwich City Football Club online newspaper, *The Pink-Un*, reports, on 29th December, that Norwich supporters were incensed by having their achievement of a two-goal lead against Tottenham Hotspur in the previous day’s match, reduced by VAR to a one-goal advantage through a millimetre offside decision.¹⁰

Tottenham would later score a goal that meant the match ended in a draw. Their reporter

⁹ Collins and Evans, 2008, 2012

¹⁰ <https://www.pinkun.com/calls-to-scrap-var-intensify-among-norwich-city-fans-1-6443493> I have since made my own approaches via the Premier League’s website but await a response.

explains that when he contacted the Premier League to ask a series of 10 questions about how the decision-making works (interestingly, without including the question of error), they refused to provide any on-the-record answers. There does seem to be a culture of secrecy and concealment when we get to technical questions and questions of possible error and this seems to be why it is not a salient issue for reporters and commentators.

The clash between scientific and non-scientific cultures, or ‘forms of life’.

Scientific culture is characterised by a quest for the truth of the matter and this implies sufficient openness for truth to emerge through a process of organised criticism; if others don’t know what is going on, then they are not in a position to criticise.¹¹ But even where science and technology are at the centre of things, other values may dominate. An exemplar for the situation in sport is the debate over the effectiveness of the Patriot missile in the first Gulf War, in particular, its effectiveness at shooting down Iraqi Scud missiles aimed at Israel. A Congressional hearing after the war concluded that they could not be certain that more than one Scud was destroyed even though in the course of the war, it was being claimed that all, or nearly all, of them were destroyed; even in the course of the Congressional hearing certain interested parties continue to maintain that the Patriot had been a highly effective weapon.¹² And it had been effective so long as one looks, not at the proof of its ability to destroy Scuds, but at its ‘indirect effects’.

¹¹ These values were first described by Robert Merton (1942, 1979) but Collins and Evans develop them in their 2017, *Why Democracies Need Science*

¹² The 6hr 18 minute Congressional hearing can be found at: <https://www.c-span.org › video › patriot-missile-performance> The whole story is told in Collins and Pinch, 1998, chapter 1 (see also the Introduction to that volume for an explanation of how the Postol claims (see below) figure in the account).

These were, first, to keep Israel out of the war given that the population considered they were being defended against the Scuds and so retaliation did not become a political imperative, and, second, the deployment of the Patriot was paving the way for the development of the ‘Star Wars’ anti-nuclear missile system. Success in both of these indirect aims required that careful analysis of the ‘errors’ in the claims about the Patriot’s 100% accuracy not be publicised or analysed too deeply. The following incident is reported to have taken place during the war:

When an Israeli officer suggested publicly disclosing qualms about Patriot, Avraham Ben-Shoshan, the military attache in Washington, snapped. "You shut up. This is the best weapon we've got against the Scuds because it's the only weapon. Why tell Saddam Hussein that it's not working."¹³

Likewise, if errors in complex match-officiating technology become widely discussed it will reduce its effectiveness in respect of indirect aims such as to have a ‘weapon’ to stop arguments with umpires – after initial arguments, it seems to have become 100% effective in this regard in tennis – and to pave the way for the continued use of the technology and, possibly, the development of further such technologies.

Applying the philosophy of digitisation: offside and the snick

The fact of the matter is that error is not a lastingly salient topic in the debate about the much disliked offside technology. We know that in the Premier League, a goal has been

¹³ Atkinson, 1992, p 278

disallowed for being 2.4cms offside with a margin of error of 13 centimeters! And we know that this has had no significant impact on the subsequent use of offside technology in VAR, not even being widely mentioned where the invalidity of millimetre offside decisions was being discussed. If it is not the potential errors, what is it that makes the technology seem problematic? Why were people questioning whether offside decisions to the level of exactness claimed by VAR should be made at all, even if they were accurate; their instinct was that this kind of judgement of offside decisions was wrong but I want to try to find a deeper philosophical foundation for this instinct.

It is not a straightforward problem because not all exact match-officiating technologies attract this kind of criticism among the public, commentators, or even the current author, ‘snick-detectors’ in cricket being an example. The author has heard no complaints about, and is himself inclined to support, the technology aimed to disambiguate the question of the snick in cricket even though, in this case, everyone knows it is not completely accurate and technical errors are a matter of discussion among commentators. There are many other instances where complex technologies do seem acceptable in spite what has been said about the technologies in Table 1, but let us start with the difference between the snick and offside.

In cricket a ball may be bowled and the batter, standing in front of the wicket, or ‘stumps’, may try to defend the stumps or hit the ball productively with the bat; if the ball hits the edge of the bat and flies on, to be caught by the ‘wicket keeper’ or another fielder standing behind the wicket, this is ‘out’ in virtue of ‘caught behind’. A slight contact between bat and ball is known as an ‘edge’ or a ‘snick’. It is sometimes hard to know

whether the ball has actually brushed the bat or narrowly missed it and, traditionally, the umpire makes the decision. New technologies have been developed to try to aid the umpire.

At the time Table 1 was first worked out, the technology was a combination of what were known as ‘Hot-Spot’, which used infra-red cameras to detect the heat caused by friction between the ball and the edge of the bat, and ‘Snicko’, which used a microphone to detect the slight sound of the impact (see Table 1 column 4). Since then, Hot-Spot has fallen into disuse as it was expensive and was known to be unreliable in very hot weather and if the edge of the bat was greasy while, in English cricket anyway, commercial changes have led to Snicko being replaced by ‘Ultra-Edge’, though the technology is basically the same. I’ll discuss the sound-based technologies, and refer to them as ‘snick-detectors’.

Commentators, the public, and this author are tolerant of the evident flaws in snick-detectors: at the moment the ball passes the bat, sounds can be made by the bat hitting the ground or the bat, or ball, hitting some part of the batters clothes or equipment, and these sounds may be hard to disambiguate from a genuine ‘snick’.¹⁴ These flaws are tolerated in spite of these technologies having a high level of indirectness.

Perhaps one of the reasons for the lack of objections to this technology is that it is ‘transparent’. The sound that is detected is presented on TV as an oscilloscope trace side-

¹⁴ If the ball hits the batters gloves it counts as ‘out’. The author often wonders if a sound would be made by the air compressing and explosively decompressing as a ball passes very close to the bat at high speed, but has not heard this problem discussed.

by-side with the frames showing the ball approaching and passing the bat so that viewers as well as match-officials can judge both simultaneity and shape of the trace. It is generally agreed that the ball hitting the bat will lead to a sharp, spikey, trace whereas the trace from the bat or ball hitting anything else will be more diffuse. In cases of ambiguity, viewers can see the problem, commentators can discuss it, and it will be rare for a viewer to think they could be sure of doing better; there is no attempt to hide what is going on with virtual reconstructions. There is no ‘show trial’, just a trial whose possible flaws are evident to all – justice (or otherwise) is being seen to be done even though exactness is visibly not being achieved. Thus, while the technology is complex, it still brings the viewer into the decision and this gives the decision the quality of something more direct. Let’s call this ‘transparency’.¹⁵

But I want to argue that though transparency helps to make snick-detectors, and any other such technological devices, more acceptable, there is a deeper issue to do with the philosophical understanding of ‘digitisation’ or ‘continuity and discontinuity’, which is itself embedded in a very significant and wider clash of cultures, or ideologies already mentioned – that to do with rule-based decisions versus human judgements.

¹⁵ On 6 January 2020, in the test match between South Africa and England in Cape Town, the South African batsman, Elgar, was given out, ‘caught behind’ but immediately challenged the decision. The snick-detector showed the tiniest spike as the ball passed the bat but both commentators agreed that it was indecisive and could have been caused by Elgar’s elbow hitting his pad at the same moment. But it was argued, correctly, that there was nothing there that would allow the TV umpire to over-turn the on-field umpire’s opinion – it was not a glaring error. These things seem to work pretty smoothly in cricket where the unavoidable element of judgement in this kind of decision-making seems better understood.

Match officiating decisions are about turning streams of human activity into a set of discontinuous states. Referees and umpires, along with the social and technological systems in which they are embedded, are given the ‘ontological authority’ to digitise the world:¹⁶ they are given the job of transforming sets of unfolding events in the world into exclusive classes, ‘out’, ‘not out’; ‘offside’, ‘onside’; ‘goal’, ‘no goal’; ‘penalty’, ‘no penalty’; ‘winner’, ‘loser’, ‘dead heat’ (three possibilities there not two), and so on. Sometimes the events that have to be digitised are already discontinuous – ready digitised, as it were – and sometimes they are not. ‘Golf ball in the cup or not in the cup’ is discontinuous and the difference is so obvious that there is normally no need for match officials to involve themselves in the decision.¹⁷ Penalty or no-penalty, on the other hand, is continuous and the referee’s job is to make a *judgement* which aligns with convention and *assigns* which class it falls into. Catch or no-catch is discontinuous and the umpire’s job is merely to *observe* which class it falls into and report. Unfortunately, it is often hard to observe a snick so the umpire is forced to make something close to a *judgement* which *assigns* the observation to a class, and snick-detectors are attempts to turn *judgements* back into simple *observations* – a widely lauded aspiration even if it is only a partial success. No-one doubts that what happened was either a catch or not a catch – one of two states has obtained – and the easier it is to see which it was, the

¹⁶ Collins, 2010a

¹⁷ Readers should be able to think of many other examples, such as pins falling in skittles or bowling, darts thrown into beds separated by wire frames, bails falling to the ground to signify that the wicket is broken in cricket, and so on.

better.¹⁸ It is hard to think of any reason, organisational or financial aside, why the use of technology to make it easier to see what happened in the case of a snick would be objectionable.

Now, let us consider the sport of curling, where things are just a little bit harder. We'll pick curling because things are slow and straightforward. In curling the aim is to slide stones along the surface of an ice rink to finish as close to the centre of a target – 'the button' – as possible. Any stone that counts must be 'in the house' – that is, it must be at least touching the outer edge of the target.

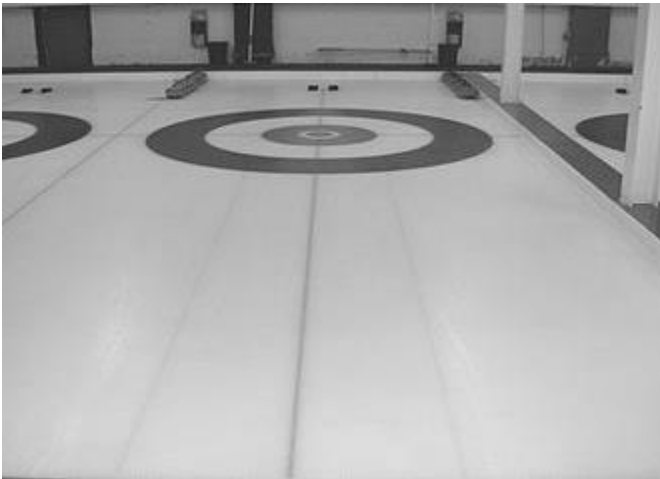


Figure 5: A curling rink

A number of stones are projected by each team. The aim and scoring is similar in principle to bowls, where the score for each of a number of 'ends' is the number of legitimate projectiles that are closer to the centre of the target than any of the opponent's projectiles. The rings of the target help with the decision about which stones are closest

¹⁸ There is no need to worry about whether the difference between touching and not-touching the bat is a physically discontinuous matter at the atomic level, we need only agree that this is how we think of it.

but distance is a continuous variable even if ‘closer’ or ‘not closer’ (or dead heat) is conceptually digital – that is to say, a stone which is a lot closer does not count more than one that is only just closer. Nevertheless, it remains that because distance is a continuous variable there can be disputes about close calls:

A stone is ‘in the house’ if it lies within the 12-foot (3.7 m) zone or any portion of its edge lies over the edge of the ring. Since the bottom of the stone is rounded, a stone just barely in the house will not have any actual contact with the ring, which will pass under the rounded edge of the stone, but it still counts. This type of stone is known as a *biter*. It may not be obvious to the eye which of two rocks is closer to the button (centre) or if a rock is actually biting or not. There are specialized devices to make these determinations. <https://en.wikipedia.org/wiki/Curling>

What the specialised devices do is physically digitize the decision – they make the curling rink more like a golf green with a cup. The button has a small hole in it in which to locate a downward-pointing spike attached to one end of a narrow frame. The frame may be of fixed length equal to the radius of the target or extendable. To determine whether a stone is ‘in the house’, the fixed frame, with the spike located in the button, is rotated until the far end approaches the potential *biter*: if it touches the stone it is in house; if it slides past the stone is not in the house. To compare the distance of two ‘in-house’ stones, the extendable frame, with spike located in the button, is made to touch one stone and then rotated to the other and the rest is obvious. Here we have converted a continuous scale of distance into a digital decision by using natural objects whose length

is exact and stable – it would not work with a string made of elastic instead of the frame – and the process seems unobjectionable.

The question remains, what is wrong with offside being measured more accurately with some technical device or other that would measure things as accurately as happens in curling? And now, we are assuming, given the lack of error discussion, that the objection has to be in terms of something other than the inaccuracy, though we will return to error in due course.

The answer, I suggest, is a subtle one to do with the nature of the digital. I am going to paraphrase my own discussion of philosopher, John Haugeland's treatment of the philosophy of the digital which is based on our tolerance for residual differences between on token and another.¹⁹ My discussion turns on the value of units of currency.

Imagine we try cut a gold bar into ten equal pieces. To work out the exact value of each piece it would have to be weighed to an arbitrary degree of accuracy and slight errors in the cutting would make the value of each piece slight different. But imagine each piece is identified by a stamp bearing a symbol which certifies it to be one-tenth of the whole. If there is widespread confidence in the stamp, each piece can be swapped with any other without careful weighing – the lumps of gold are digitised – they all have the same value irrespective of slight differences in weight. Trouble can arise, however, as a result of 'clipping'. Because the gold has intrinsic value, if you clip a bit off, the clipping itself,

¹⁹ Haugeland, 1985

though it has no stamp on it, has an intrinsic value, while the intrinsic value of the stamped pieces is reduced, if clipped, and the stamp will tend to lose credibility as time goes on. Eventually the digitisation process will fail and the value of the gold pieces will revert to being a continuous feature of the world. If, however, the stamp is impressed on materials that have no intrinsic worth – such as base metal or paper – the value resides entirely in the stamp and not in the material and there is no danger to the digital nature of the world from clipping: even if coins or notes are clipped or damaged they will still be worth the same. The over-arching argument is that the key to secure digitisation is the lack of intrinsic ‘value’ of the material which bears the symbol. Haugeland expresses this by pointing to the distinction between an old painting, on the one hand, which is continually changing as it is affected by contamination and colour change due to chemical deterioration, and a printed manuscript on the other, the appearance of the print being affected by the same chemical changes, without changing the meaning of the letters.²⁰

Now, one can see that in nearly all the cases of sport that have been discussed so far, what is being digitised is more like base metal than gold. There is nothing of intrinsic value to the golf ball being in the hole or the ball hitting the bat, or one curling stone being nearer to the centre than another. Thus, we don’t think that a ball that goes into the centre of the golf hole should score more than one that topples in the side, nor do we think a hard edge at cricket is *more* ‘out’ than a ball brushing the bat, only *more*

²⁰ I argue in Collins 1990 that the difference has more to do with the way we treat these things than their intrinsic nature but that does not matter for the current purposes.

obviously out, and, as already remarked, we don't think that the stone which is a lot nearer to the centre than another should score more than one that needs to be measured. But offside is different!

In the case of offside, the substance does have intrinsic value. We do think that a player who is well offside is gaining more of an advantage in terms of being able to score a goal than one who is only marginally offside because the player who is well-offside can more easily escape the attentions of the last defender. And this 'value' is recognised in football because the rules of offside have changed over the years so that players 'not interfering with play', and therefore not giving the attacking team an advantage in virtue of their being offside, do not count as violating the offside rule. It is because offside is meaningful that we find ourselves uncomfortable in respect of whether an offside should count as offside if it is marginal; a player who is offside by a millimetre or so does not have an advantage in terms of the likelihood of scoring a goal unless a difference that small is *defined as a disadvantage by a rule*; the player who is offside by a millimetre only has an advantage so long as the punishment and reward for offside and onside is distinct from offside's value in terms of the aims of the game. That is to say, what you are trying to do in offside is equivalent to impressing a tiny and almost valueless clipping with the same stamp as you put on a tenth of a gold bar. This, I suggest, is why people feel doubtful that making the offside technology more and more accurate is the right way to go – it converts offside from something of value to something that is defined by a new kind of symbolic rule. To repeat, the value of *the symbol* 'offside' is insecure because it is not made of the kind of valueless substance that naturally lends itself to digitisation.

We can see the difference between the value of ‘offside’ and ‘the offside rule’ illustrated in Figure 6. Here we see Liverpool’s Mané marginally but, in this case, visibly, offside in a TV replay. The headed goal would be disallowed after a VAR consultation that took one-and-a-half minutes. The difference between the rule and the value of offside can be seen because the brilliance of the move lay in the cross, which projected the ball *from the side* over the intervening players’ heads onto the attacking player’s head without the player behind Mané being able to intervene; this had nothing to do with Mané’s technically offside position because the ball was travelling sideways not forwards. This becomes still more clear in Figure 7, which shows Mané actually heading the ball into the net. To get his head to the ball Mané had to move away from the goal not towards it.

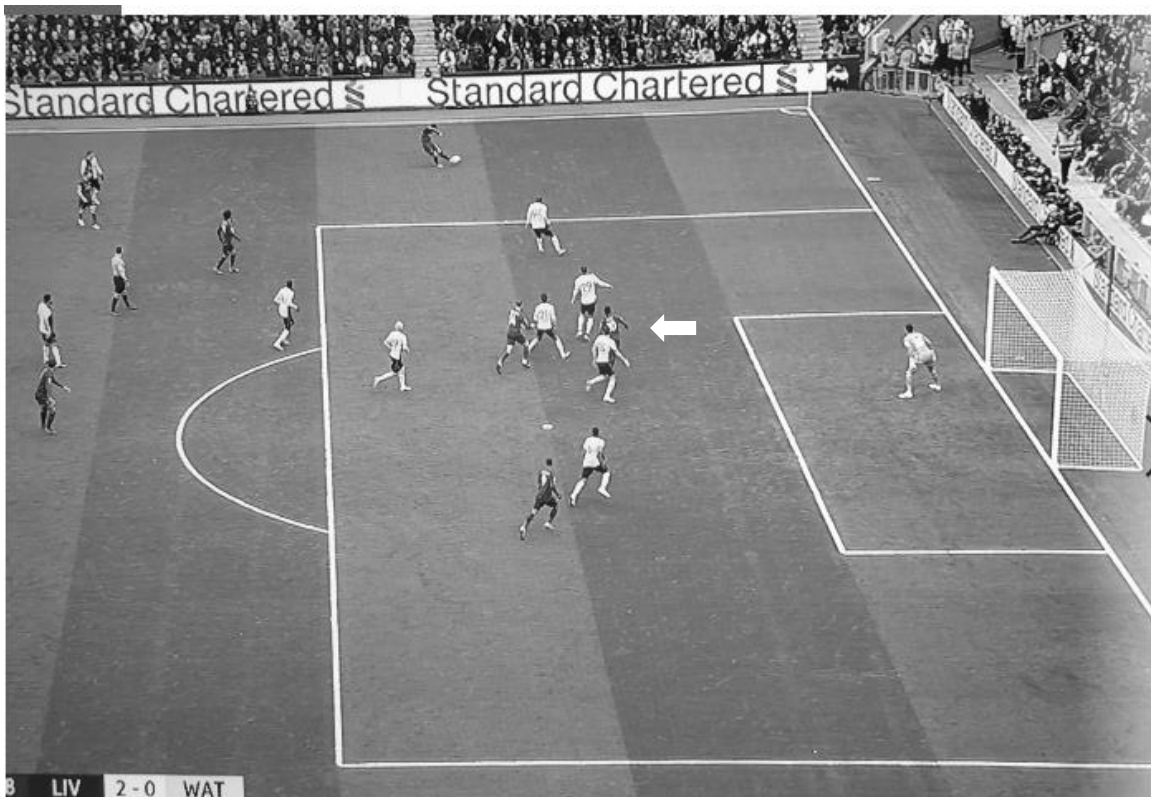


Figure 6: ‘Offside’ – Liverpool vs Watford, 14 December, 2019. TV replay of Mané (arrowed) about to head Liverpool’s second goal, which would be disallowed for offside after consultation with VAR with the displayed score on the TV screen changed back to 1-0 (49.21 into the game, ruled offside at 50.55).



Figure 7: Liverpool vs Watford, 14 December, 2019, Mané heads the goal from the cross shown in Figure 6

The match commentator remarked: *Even though it doesn't count, it was a brilliantly [manufactured] cross for the header. I'm not even going to get into the debate as to whether offside decisions that tight should be OK or not, we've all got our opinions on it.*²¹

²¹ This illustration bears on Appendix 2, which concerns the possibility of pro-Liverpool bias. Here I am going to argue that (a) Mané is visibly offside and (b) under the change of rules that I advocate, should continue to count as offside, even though he is gaining no advantage. Graham Souness (see below) would argue that Mané should not count as offside but I will argue that this could be too large a change in the rules.

We'll return to offside after looking at goal-line technology, about which I can find no significant discussion on the web, except complaints that such statements of its accuracy as there are come from the authorities, not from independent assessors.

Goal line technology

Goal-line technology uses ball-trackers to determine whether a ball has fully crossed the goal line and therefore counts as a goal. Figure 8 shows an example of where an apparent goal, as shown on TV, was ruled out by goal line technology.



Figure 8: TV replay of ‘non-goal’ scored by Liverpool vs. Manchester City, 3/01/2019; the goal was disallowed on the grounds that the ball had not crossed the line by 11.2 millimeters. It was later said that the average error in this case was 3.6mm. [Originally Figure 1 in Collins, 2019a].

Unlike offside, goal/no-goal is a naturally digital matter, there being no intrinsic value to the extent to which the ball has crossed the goal-line so long as it has fully crossed it.

Indeed, if it were practicable, a deep pit could be dug in the goal-mouth with the object of the game being to get the ball in the pit – rather like the golf-cup decision. With no pit, however, the decision is more like that in curling, where an exact measurement of a continuous variable is required but, unlike curling, the ball is moving, so no naturally-

digitised physical device can be deployed to determine its position relative to the goal line at the end of its travel. Traditionally, in cases of ambivalence, the referee made the judgment of whether the ball had crossed the line. Now, however, goal line technology ‘artificially digitises’ the measurement and is, of course, subject to error. The error is admitted but is said to be small – the average is said to be in the region of a few millimetres.

Wherever there is error of this kind there are problems because the error will vary according to the exact circumstances but the errors that are quoted are given by manufacturers or other official bodies as ‘average errors’, without any publicly visible independent verification and without any figures for range of error or ‘scatter’: given the average error what is the maximum and how likely are errors larger than the average likely to occur? Nevertheless, goal-line technology has been widely accepted by officials, commentators, and the public as a success; it produces a quick and apparently decisive outcome relayed to the referee. In this it is like the ball-tracker decisions in tennis, which have become the *de-facto* standard even though it is acknowledged, by some, at least, that they cannot deliver the accuracy they are portrayed as delivering. This kind of success is like the indirect success of the Patriot missile discussed earlier.

Goal-line technology was introduced in response to some well-publicised cases where goals were not given even though TV replays clearly showed the ball bouncing well-inside the goal-line and bouncing out again due to spin or some such. As far as UK football fans are concerned, the most notorious incident is shown in Figure 9.



Figure 9: With England trailing 2-1 to Germany in their last-16 match, one of the most famous ‘non-goals’ in the history of football is scored

Since this, and many other cases, are shown by TV replays to be clear miscarriages of justice, the obvious conclusion is to use TV replays to set things right, but instead we have goal-line technology.

Goal-line technology uses a ball-tracker to estimate the path of the ball. A ball-tracker in cricket and tennis estimates the path of the ball by extrapolating from a series of data points representing its position in a sequence of TV frames. Ball trackers were first used for lbw decisions in cricket to estimate whether the ball would have hit the wicket if it had not hit the batter’s pad first. It was later used in tennis to estimate whether the path of the ball would take its bounce-point inside or outside the line. The errors that arise depend on the frame speed of the cameras, the visible path length of the ball, the speed of the ball, the curvature of the path, any changes in the curvature, the deceleration of the ball, any changes in the rate of deceleration, the smearing of the image of the ball in a TV frame, and external influences such as wind. The path of a ball can be estimated forward of the last data point in this way only if it is smooth not discontinuous but curvature and

deceleration along with changes in those variables require a longer path-length and more data points to estimate. Any discontinuity or sudden deviation caused by, say, impact with the ground, or with a player, means the extrapolation has to start again from the beginning. This can cause difficulty for lbw because the ball will usually bounce before impact with the pad and the path length from bounce to pad – where the data points cease – can be very short and the extrapolation error-prone.

In earlier work we made some rough estimates of the potential errors in the case of lbw and tennis line-calls based on a series of assumptions about frame-speed and the like but found ourselves unable to secure information from the providers of the technology nor any readiness to admit that reports of average errors were unsatisfactory without an indication of scatter and maximum error. Nevertheless, our rough estimates were never challenged by technical arguments and appear to have influenced the way ball-trackers are used in cricket if not in tennis.²² In a recent paper I re-examined the case illustrated in Figure 8 and suggested that the level of error in ball trackers, and the very small number of cases (less than a handful), where they could make a difference in a Premiership season even if accurate, argued for their replacement with quick TV replays on grounds of logistics and transparent justice; at the moment, the viewer cannot see how the technology is deciding the issue but is instead presented with a virtual reality ‘show trial’.²³ I now think that there is a possibility that the ball-tracker errors in goal-line

²² Collins and Evans, 2008; 2012

²³ Collins, 2019a, Figure 2.

technology could be far greater than in cricket or tennis. Of course, I am working from first principles in the absence of detailed technical information from the providers of the technology so I could be wrong, but, should that be the case, it would be easy for the authorities to explain the technicalities in enough detail to show where the mistakes have been made.

A possible problem with goal-line technology

The problem for goal-line technology (GLT) is that its job is *not to* estimate the future path of a ball in relationship to a fixed point – as in the case of the wicket in cricket and the edge of the line in tennis – but to report where the path was caused to end by a moving external influence – usually, the intervention of a player. The job is to locate the position of a discontinuity in the path caused by an unknown force – we’ll call this ‘*the discontinuity*’ – and to decide whether the position of this discontinuity is such as to constitute a goal or not. Since the rule is that the ball must be fully over the goal line to count as a goal, the centre of the ball must be half-a-ball’s diameter beyond the goal line to count as a goal.

Determining this with a TV camera is quick, easy and relatively error-free when it is a matter of confirming a clear goal. This is because confirming a clear goal is not a matter of extrapolation from a number of data points but location of a single data-point – a ball in a TV frame – sufficiently far beyond the goal line (taking into account any inaccuracy involved in locating the ball’s centre within the cloud of TV pixels representing the ball, which error we don’t know, but is probably small). For example, GLT would not have allowed the mistake represented by Figure 9 because the very fact that TV viewers can

see that the ball bounced beyond the goal line shows that GLT could avail itself of a data point beyond the goal line. In a circumstance like this GLT could claim to be a success if it was quicker than looking back at a replay – which it is. The difficulties for both TV replays and GLT arise only when there is no data point well clear of the goal line, as in Figure 8. In these case it now seems that the errors could be very large.

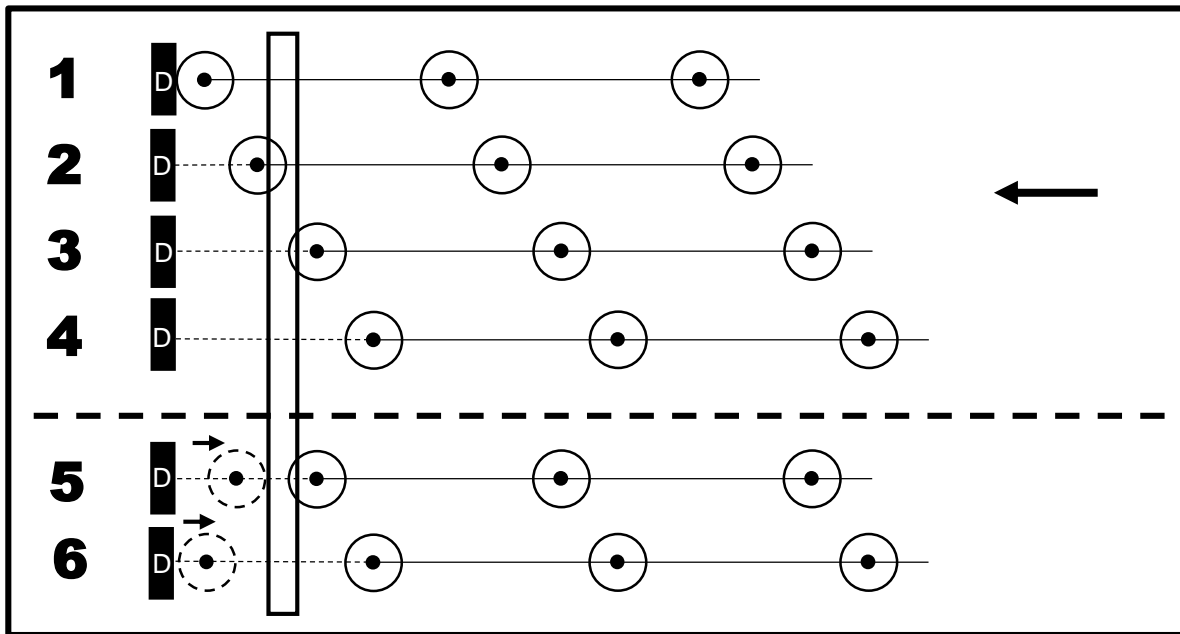


Figure 10: Schematic representation of the last three pre-discontinuity data points with a fast-moving ball and a camera frame-rate of 50fps; dashed circles below dashed line are post-discontinuity data points

The source of these large errors is the same as that of the potential errors in the offside decision and has to do with the frame-rate of the cameras and the speed of the ball.

Figure 10 illustrates the problem with a series of schematic possibilities. Line 1 of the figure is a very rough representation of the last three data points (TV frames), prior to the discontinuity, representing a ball travelling from right-to-left in a straight line at about 100 feet per second with the camera running at 50 frames per second; the goal line is shown as a long vertical, unshaded, rectangle. The ball will move about 2 feet between each frame so we are looking here at events that happen over about the last 6 feet of

travel. The path of the ball is terminated by an outside force – the discontinuity – represented by a black rectangle labelled ‘D’. This might be some part of a defending player. In the case represented in Figure 9, the terminating force was the ground, the ball having back-spin, and or hitting a divot, which caused it to bounce out of the goal again.

The problem is the same as it is with offside. The exact position of any data point in line one of the figure depends on the exact timing of the frame, but this is random within a frame interval: it depends on the exact moment that the camera started rolling. So the final three frames could be as shown in lines, 2, 3, or 4, or anywhere in-between and it is impossible to know which instantiation of this range we are looking at when we look at the last data point. As can be seen, on these assumptions, three out four times there will be *no* data point that indicates a clear goal even though it was a goal.

What we have not yet taken into account is post-discontinuity data points. Even if the ball bounces back in the direction it came from at the same, 100 feet per second, speed, in lines 3 and 4 there would not be time for it to touch the goal line again before the next data point was registered, so there would still be secure evidence of a goal as shown below the dashed divider in lines 5 and 6. If events transpired as in Figure 9, where the ball was bouncing down from the cross-bar and back up again, so though it was moving pretty fast, its horizontal speed was slow, the distances between data points would be much shorter so there would have been more chance that there would have been one or more data points beyond the goal line. In other cases, the goalie might have caught the ball and slowed it, or it might have bounced sideways off a player and this would have slowed its left-to-right speed and given time for another data-point indicative of a goal, or

the ball might have been moving much slower in the first place, as it was in the case of Figure 8, where the ball looped into the goal – this makes the chance of a correct determination of ‘goal’ much higher.

But let us imagine the forward speed of the ball was 10 feet per second in Figure 8, then, on the 50 frames per second assumption, the ball would have moved in the region 6 centimeters per frame and this would still swamp the claim that the ball failed to clear the goal line by 11.2 millimeters because under different circumstances the final data point *could have been* 6 centimeters further on. Double the frame speed and halve the ball speed and the possible error is still 15 millimeters. And what we don’t know, since we are told only average errors, is whether ball speed is taken into account when calculating the error so that the technology is hopeless when the ball is moving fast and so on; so far I do not know of a case when GLT announced that the error was too large for it to make a determination but if the variation of error is taken into account that would surely happen quite often.

But going back to the actual case represented in Figure 8, here the discontinuity (the defender’s foot) is claimed to much further to the right or it could not stop the ball before it reached the goal line; it is in the region of a ball’s diameter beyond the goal line so it seems almost certain that any post-discontinuity data points will be less than that distance from the goal line, in the ‘no-goal’ region. The last usable data point will be at, or prior to, the discontinuity. If a ‘goal’ is registered only if the last data point is beyond the line, then the technology is subject to the errors indicated in lines 1-4 in Figure 10, without amelioration by post-discontinuity data points, and however slowly the ball is going the

errors will swamp the claim of ‘no goal’. Furthermore, all this assumes the ball is visible before and after the discontinuity. Suppose the goal-keeper ‘prevents’ the ball from going over the line by diving on top of it, or some such – then there will be no post-discontinuity data points nor even usable pre-discontinuity data points however favourable the timing of the final camera frame.

There is one other possibility. If, in a case like that represented in Figure 8, there are enough post-discontinuity data points to estimate a trajectory and the same for pre-discontinuity data points, it would, in theory, be possible to estimate two trajectories and estimate the furthest point behind the goal line of the centre of the ball to be their intersection. But this estimate would combine the typical ball-tracking errors in both estimates resulting in very large potential errors.

One disturbing possibility is that GLT indicates ‘goal’ only when there are post-discontinuity data points beyond the goal line or two tracks with an intersection well behind the goal line and indicates ‘no-goal’ when ‘goal’ is not certain; the justification might be that since goal or no-goal is a binary choice in theory, then if it is not a certain goal, it must be ‘no goal’. Such a procedure would obviously give the benefit of the doubt to ‘no-goal’, leading to many cases of ‘goals’ being given as ‘no-goals’. We simply do not know how GLT operates under these various circumstances or whether we have overlooked something, but the only way to know is to have the technology and the testing procedure explained in great detail, informed by scientific values which allow technically informed criticism, rather than those non-scientific values which emphasise concealment.

Now, this analysis, which indicates that there could be really large errors in goal-line technology, seems hard to uphold given its wide acceptance. For example, in the article in the *Daily Mail* quoted above, Danny Murphy, ex-Liverpool player and regular football commentator, who has been complaining about offside decisions in respect of VAR, is quoted as follows:

My preference would be for VAR to be scrapped in all instances except goalline technology. I just don't believe offsides are the clear and definitive "yes or no" that the referees claim they are.

In short, it seems, crazy, for an outsider, unable to gain access to crucial features of the way VAR is operated, to try to use first principles to cast doubt on a technology offered by technically expert firms and tested (so we understand) under the supervision of the sports authorities, and gratefully adopted by them as the solution to the goal-line problem and accepted even by critics of VAR such as Danny Murphy. But it seems nearly as crazy as for an outsider, to criticise ball-trackers in the first place, or the accuracy of the offside technology (only retrospectively discovering that the criticism is right) or for Theodore Postol, an outsider, to question claims about the efficacy of the Patriot anti-missile, missile used to shoot down Iraqi Scud missiles in the first Gulf War, in 1990, one side stating that nearly all the Scuds were eliminated while Postol said that none, or almost none of them were brought down.²⁴ So we have to be careful, as in the case of

²⁴ Postol, 1991, 1992, first seems to have brought attention to the problem but the Congressional Hearing shows that certain military advisors came to share his opinion.

any ‘whistleblower’, about accepting the charge of craziness. The simple way for these possibilities to be dismissed is for the firms offering the technologies to explain exactly how they work and how their errors are judged and describe the scatter of the errors, and how they relate to specific cases, not offer something meaningless, like ‘average error’.

Judgements versus rule-based decision-making

The argument about the proper use of VAR is set in the context of the tension between two kinds of values, scientific on the one hand, and commercial or political on the other, but there are two other competing cultures, or ‘ideologies’ to be taken into account – ‘human-judgement’ versus ‘rule-based decision-making’.

The tension between judgements and rules shows itself in many of the domains found in modern societies. Wittgenstein points out that ‘rules do not contain the rules for their own application’. This means that any attempt to apply rules always involves matters of interpretation. For example, suppose you are asked to write down the next number in the sequence ‘2, 4, 6, 8’, by following the rule ‘add two’. We automatically think the number we should write is ‘10’, but other interpretations include ‘82’, ‘28’, 8two’, ‘two8’ and any more you can think of which could be interpreted as an application of the rule by someone ingenious but inclined to be awkward.²⁵ Mostly, unconscious social conventions remove the plethora of other possible ‘literal’ interpretations from consideration without anyone noticing. Again, consider the less subtle question of

²⁵ The Wittgenstein reference is his 1953; the ‘continue the sequence’ example is worked out under the title ‘awkward student’ in Collins, 1985/92.

measuring a person's height. This can be used to show the difference between exact computer/calculator arithmetic and human-executed arithmetic. If my height is 69 inches and there are 25.4mms to the inch a calculator will show my height to be 1752.6mm. But that is not my height – my height is 175cms, because in human societies it does not make sense to measure height more accurately than that – that, again, is the unspoken convention.²⁶ Turning back to sports, even the iconic digitization of the golf cup depends on the players not damaging the edge of the hole too much (how much cannot be defined but rounding the edge before taking the shot to encourage a ball to fall in seems wrong), while the measure in curling has to take less than a certain time to complete (what that time is can't be defined but obviously, an hour is too long). Thus using defined rules to 'improve on' certain mutually understood conventions depends on judgement of the application of other social conventions.

This is well-understood in the sociology of organizations, where it is recognized that bureaucracies work smoothly only when rules are applied flexibly and creatively and it is well-understood by those undertaking the powerful form of industrial action known as a 'work to rule', which interprets rules in a pedantically bureaucratic way without any flexibility. But this is not something that is understood in sport-officiating technology circles.²⁷

²⁶ This example is first presented in Collins 1990, pps 55-56

²⁷ Or in artificial intelligence circles for that matter. Terry Winograd, one the pioneers, and later critic, of AI research, criticised his own highly successful program for shifting

The Wittgensteinian way of thinking about rules and the more widespread mathematical way of thinking about them represent what we can call two ‘cultures’ of refereeing, the one mapping onto the idea that refereeing is about transparent justice in making judgements and the other mapping on to the idea that refereeing is about accurate application of the rules. The second kind of idea is extraordinarily seductive and grows ever more seductive as areas of traditional judgement are replaced with technical devices. A university statistician, with whom I discussed the problem of offside, exemplifies how hard it is to avoid the idea that the logic of decision making is underpinned by the aim of accurate application of rules:

Statistician: Whenever a binary decision depends on a continuous variable (in this case, the relative position of two relevant players) then a “cut-off” is inevitably involved ... moving the cut-off (eg from zero to a foot in front) doesn’t change anything – a foot is then the new zero ... Even if you make the cut-off fuzzier, by relying on the ref’s naked eye instead of VAR, the cut-off is still there – it’s just that now whether or not you are just above or just below the cut-off relies on some extra random noise as well.

This viewpoint is echoed in the commonsense of many supporters of VAR’s offside technology. For instance, ex-Liverpool player, Jamie Carragher, now frequently a

blocks around in response to typed commands, as working in a ‘micro-world’. A recent analysis is Collins 2018.

commentator on football programs, though full of doubts about VAR, said after watching Wolverhampton denied a goal by a millimeter or two on 29 December:

If you go back to football when it was first started, offside was about stopping people goal-hanging, not about someone's little toe or armpit being offside. Now VAR has been brought in, and this is the biggest thing, I think, [that] winds supporters up, and does it wind me up? – Yes it does a bit because we're losing goals [Compère interjects: '22 this season to marginal offsides'], but if you listen to supporters – people are chatting about it in the stadium – you listen on social media – everyone's got an answer. ... the offside is the biggest thing that's killing VAR ... but no-one has given me an answer, or a theory, on how you make the offside run better ... but I just want to get to the actual VAR of it. Offside, no matter what your rule is ... it will still be about 'that' [indicating a tiny gap between finger and thumb] ... offside will always be about a line and whether you're that side or that side [indicating with hands]. ... it will always be about being one side of a line or another.

The logic of Carragher's remarks is hard to avoid, but what I am arguing is that offside should not be seen as a binary decision – one side of a line or the other – based on a continuous variable with, at best, 'extra noise', but should be seen as, *essentially*, a matter of human judgement – that is the ontology of offside. Forgetting about the judgement of whether a player is interfering with play, and just concentrating on the 'judged-to-be-active' players, offside, which is always *described* in terms of a rule about the exact position of the players, is governed by a convention that has always said that this is to be judged by the human eye not an exact measure: 'only if a player looks offside is the

player offside’ and that is how it should stay; that’s not ‘introducing noise’, that’s changing the definition to something like ‘a thing that cannot be measured exactly but can be proven beyond reasonable doubt’ – just as in the case of a just decision in a courtroom; this would resolve all the current problems.²⁸

To those of a mathematical mind-set, such as the quoted statistician, or those seduced by the logic of the formal description of offside, such as Jamie Carragher and many others, this solution will seem to introduce problems not resolve them by moving from ‘objectivity’ back to ‘subjectivity’. But being able to measure does not force you to measure, and defining in terms of something exact, does not force you to implement it that way. For example, a binary decision in respect of a continuous variable is speeding; in a 50 mile per hour limit, 50.1mph is speeding while 50mph is not – the mathematics are binary, the description is binary, though the variable is continuous and there are technologies for measuring it. But in many countries the convention is that there is no need to implement it as exactly as one side of the line or the other. In such countries it would be thought outrageous to fine someone for speeding at 50.1mph or even 51mph because that much speeding is not gaining anyone an advantage; defining it that way is likely to increase danger by causing drivers to pay more attention to the speedometer than to the road; if fines were administered for 51mph it would be the rule not the speed that was generating the disutility, or utility where speeding fines are used, primarily, to

²⁸ Collins and Evans, 2012, liken the effect of sport on the culture of society to the ‘CSI effect’ – where misleading TV portrayals of the decisiveness of forensic science utilised in crime scene investigations has misled juries to expect too much from forensic evidence.

generate revenue, A change of this kind along with a change in the technical means to implement it, such as hand-held radar- or laser-guns, changes the purpose of speed measurement from safety to money-making.²⁹ Around 10% excess speed is probably the kind of definition of safety-motivated speeding that people are ready to accept, but a crucial part of the idea of speeding is that this is never exactly defined – it is all a matter of judgement on behalf of drivers and authorities. So, there is nothing in the nature of binary lines imposed on continuous variables that makes the interpretation offered by the statistician, VAR, Jamie Carragher, and many others, unavoidable; judgement is everywhere.

As already mentioned, there is a lot of difficulty in judging offside at the speed of the game given that two remote events have to be seen together, so traditional referees make many mistakes, some of them big mistakes, and some of them used as examples in our 2016 book to argue the need for the introduction of VAR to avoid this kind of injustice. But these mistakes are not an indicator of noise, they are an indicator that it is hard to make the right judgement when things are hard to see; at high speed it is hard to see whether a player even *looks* offside. TV replays make it much easier to judge correctly, so with their introduction we TV viewers started to be able to see when mistakes were being made. But what VAR should be doing is putting these mistakes right, not introducing a whole new meaning for offside. And TV replays can put the mistakes right quickly and easily. Note that, as the statistician said, if the attempt is made to solve the

²⁹ Though in the UK hand-held devices were abandoned when they were found by the courts to be subject to error.

VAR problem by redefining offside in terms of a minimum distance, or a body-width, or reversing the definition, as Graham Souness suggests, to being onside if any part of the body is onside, it will return us to the same difficulty but located in a different place.³⁰

The crucial piece of understanding is that in the case of offside, the mathematical description of the world is wrong just as a mathematical description would be wrong if it were applied to penalties, which nearly always involve a judgement of intention, or seriousness. Surely, no one would try to apply a mathematical description to penalty decisions (but see below). But because the *description* of offside is in terms of a binary distinction, people get sucked into the idea that we are compelled to instantiate with mathematical exactness – but it just isn't true.

The solution for offside, goal-line technology and VAR in general

VAR should not be abandoned – it is necessary to correct the clear errors that referees make and enhance the justice of decision-making, but it should be used in ways that follow the principles described in our various papers, our 2016 book, and indicated in this paper. The principles are based on JAC – standing for ‘justice and continuity’ – and RINOWN –standing for ‘right if not wrong’. These principles are:

³⁰ In the same program quoted above, ex-Liverpool footballer, Graham Souness, suggested changing the rule to a player being onside unless *no part* of the body was behind the line. He said that this would increase the number of goals but it would be a large and meaningful change in the rules and would not resolve the problems of long delays while attempts were made to make error-prone measurements.

1. The aim of sports officiating should be to ensure **justice not accuracy** (the first part of JAC).
2. Justice should be not only done, but *seen to be done*, so decision-making should be **transparent**.³¹
3. The aim should be to make technically assisted sports as similar to traditional sports as possible (**continuity** is the second part of JAC).
4. The decisions of the match official in charge should be taken to be right if they cannot quickly be shown to be obviously wrong.

To this we can now add a fifth and sixth principle:

5. Good measurements involve **natural binaries** not fake or false digitization.
6. Decision-making should be a **rapid** as possible.

In the case of offside all these principles are currently being violated: VAR offside is obsessed with accuracy not justice; its rulings are show trials which obscure the errors so justice is not seen to be being done even if some people think it is; it is changing the traditional meaning of offside and it takes far too long to reach a decision because, essentially, it is ‘working to rule’ rather than interpreting the rule flexibly. Finally, rather than employing a natural binary to make what is mistakenly assumed to be a natural binary distinction in a continuous variable it is using the equivalent of a piece of elastic of

³¹ In Collins, 2019a, another principle argued was that the more ‘direct’ sports officiating technology was, the better. That remains true but we have argued that transparency can ameliorate indirectness so that is probably the over-riding principle.

unknown stretchiness as a ruler, and passing it off as a binary. All these problems could be fixed with quick television replays shown to home TV viewers and players, referees, and crowds on big screens at the stadiums. Big screens at the stadiums would also allow referees to make the final decision, reversing their own decision when they thought it appropriate, without making a special excursion to the side of the pitch, speeding things up still further, and without removing authority to a remote and invisible location.

There remains one unresolved problem here and it is one that we failed to notice in our 2016 book. In that book we argued that assistant referees should not flag for marginal offsides because it could disturb a game that should continue. A startling instance of this took place in the game between Sheffield United and Newcastle on 5th December 2019 and the incident is illustrated in Figure 11.



Figure11: 'Onside' -- Sheffield United vs Newcastle United, 5 December, 2019. Newcastle players are in the darker strip. The vertical arrow points to the passing player; the horizontal arrow points to the Newcastle player, Shelvey, who will go on to score.

The player who will run on to score is actually *behind* the player who has just headed it towards him and both are yards behind the Sheffield player who raises his arm to indicate an offside offence and visibly behind two other Sheffield players. The assistant referee makes a gross mistake and raises his flag decisively causing the Sheffield players to stop trying. Shelvey runs on fairly slowly and shoots the ball without passion past the stationary goalkeeper into the undefended net. The commentator says that Shelvey should be shown a yellow card for time-wasting. But then VAR reverses the offside decision, initially to everyone's amazement. The first fault here is that the Sheffield players should have 'played to the whistle' – the referee had not blown it to halt the game but the Sheffield players had read the future incorrectly. But it is hard to play to the

whistle when an offside flag has been raised so decisively and the consequence would have been quite different in the traditional game; this is clear from the commentator's remarks. The second fault is the instructions given to assistant-referee, which are to raise the flag even for marginal offsides – or so I would have said until recently but now things seem more complicated. In our 2016 book (pps 125-6) we wrote that for marginal offside the game should not be stopped nor the flag raised. Only if the TV judge concluded that an offside decision was in order would play be pulled back. With clear offside, things would continue as they do now with the review taking place during the stoppage created by the on-field decision. Referees would have to be discouraged from stopping play for these events unless they were really sure they were right. But this now seems unsatisfactory: no one seems to have solved the problem of when to stop the game in the case of offside given that a review is possible. On the one hand there is the case of Figure 11 which argues for no stopping or flagging until there is a natural break in play; on the other hand, TV commentators continually point out that if the game continues after a clear offside, players could be injured while trying to score a goal which will later turn out to be void; with injuries crucial in the Premier League, this would be a tragedy. The solution has to be no flagging on the field, but TV-based decision-making executed as fast as possible. This can be done only by reversing the order of action of referee and TV referee in the case of offside. TV referees should have the first call, communicated to the referee via an earpiece, since the TV referee can provide a decision in a few seconds, even taking advantage of a replay if necessary, with confirmation or reversal by the on-field referee looking at a big screen. There should be no cases where the game is stopped when it should not have been stopped, and only very rare cases where a referee concludes

that applying the benefit of the doubt was a clear and glaring mistake and a goal should be ruled out retrospectively for a clear offside; these will be the only cases where injury is risked without justification.

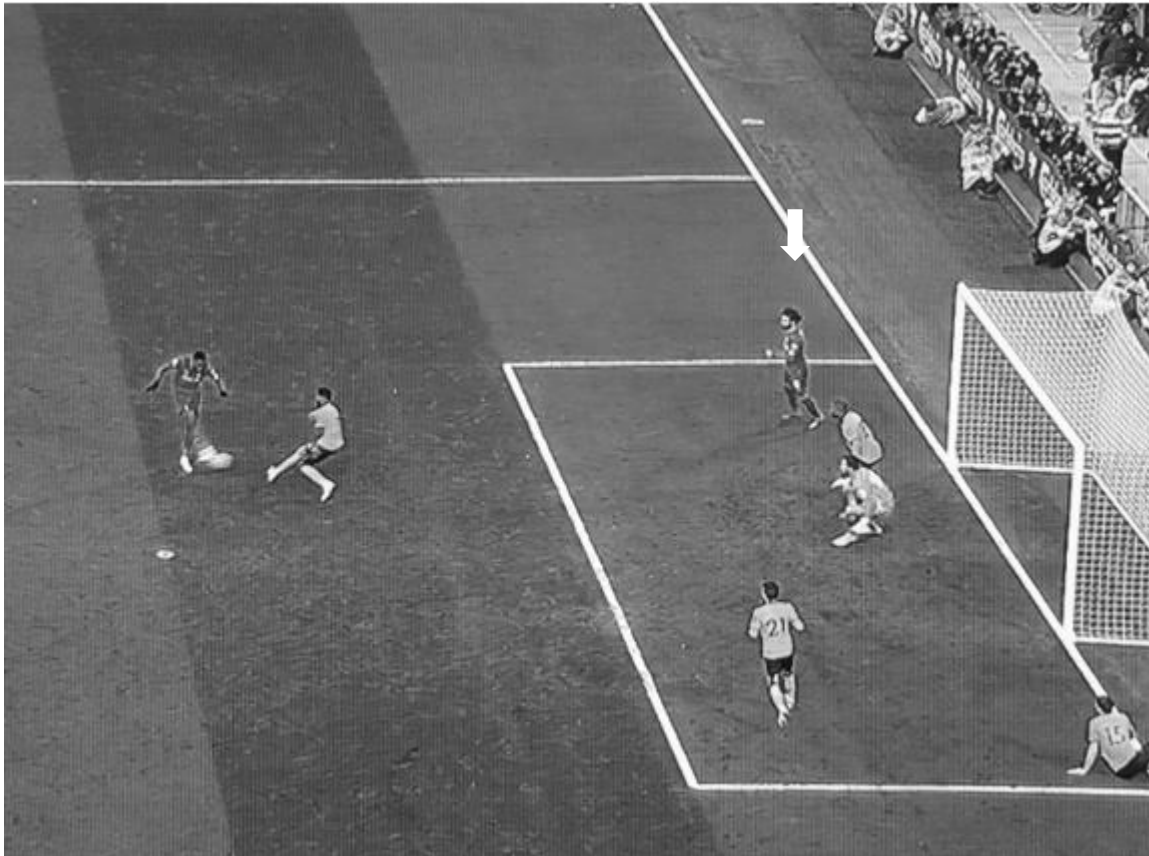


Figure 12: Liverpool vs Watford, 89.26, Salah's (arrowed) last-minute goal from a sideways flick through the legs of the defender would be given, but ruled onside only after a 2-minute delay.

Two examples have been provided where offside decisions based on TV replays would have worked perfectly under the current binary rules plus the modification must 'look onside/offside'. Figure 6 shows Mané' to be visibly offside even though he was gaining no advantage from it; should the TV judge have decided that 'benefit of the doubt' should apply here and the referee reversed it after a further consideration, no harm would have been done since the goal was scored almost instantly. Figure 11 shows that TV was more than adequate to show that Shelvey was onside. Likewise, with Figure 12, above,

which shows the second Liverpool goal in the Liverpool-Watford match; it is easy to see that Salah (arrowed) is onside, certainly under a benefit of the doubt rule. In actuality, the goal was awarded only after a two-minute VAR delay leading the commentator to remark: *It's totally killed the moment of a brilliant Mo Salah goal.*

Should there be no technological aids at all beyond replays for judging offside? In the examples of easily judged offsides, the lines mowed into the grass do give some aid to the eye. There seems no reason why a calibrated virtual grid of this sort should not be overlaid on the pitch for the replay, provided it can be done instantly. The crucial thing is that the lines should be widely spaced and the action should not be taking place anywhere too close to a line as this would tempt the viewer to try to make too accurate a judgement.

Goal-line technology

The only example of the use of goal-line technology in this paper (Figure 8) is drawn from the January of the last football season. In my sports watching in this football season I have not encountered it nor any discussion of it except for occasional favourable comment taking it as an example of how VAR should work. This is no surprise since, as we showed in our 2016 book, the question of whether a ball has crossed the goal line into the goal is hardly ever an issue and, when it is, there is a small to vanishing chance that a quick TV replay would not resolve the problem. Nevertheless, because people think it works it has become part of the 'accuracy disease' – a disease which, as the next section will argue, is spreading, and needs a cure. So how does GLT stand in relationship to the 6 principles outlined above? It violates five out of six of them: as Figure 8 shows, it violates principle 1 by favouring accuracy over justice since hardly anyone would

consider it justice that a ball so far into the goal that it would always be counted a goal by a fair referee in the traditional game would be discounted on the basis of being a centimetre short; it violates principle 2 because justice is not seen to be done since its judgment process is hidden and represented in a show trial; it violates principle 3 since it moves away from the judgements made in the traditional game even while trying to stick to the letter of the law; it violates principle 4 because it over-rules the reasonable judgement of the referee with a technical measurement; and it violates principle 5 because, at least according to our analysis, it uses a piece of elastic of unknown and concealed qualities rather than a natural binary as a measure. The only good thing about it is that it is quick, but in a perverse way, this is a bad thing since it is paving the way for more such implementations.

Rules based culture as a disease

Measuring how we act too exactly instead of judging in more diffuse ways can cause changes in many areas of life. We have already mentioned speeding as an example and the same goes for exact implementation of parking violations with no area of tolerance, or the same for bank overdrafts; this kind of thing is changing the suspicion of pedantic bureaucracy that has long been admired as part of UK culture. Another notorious example of the way damage can be done, is ‘teaching to the test’, in the field of education. When the value of schools is assessed by regular tests of the pupils’ performance, teachers begin to coach for good results in the tests rather than ‘educating’

for broad and rich understanding – education becomes ‘hollowed out’.³² Thus does the reach towards rule-based decision-making have its effects on societies as a whole with some societies being notably more bureaucratically inclined than others. Faced with what seems like the hard-to-explain inability of VAR referees to act in accordance with their job description – intervene only when the referee has made a clear and obvious mistake – it could be that the determination to ‘get decisions right’ and value accuracy above justice is spreading, like a cultural infection, even into the domain of those decision that are acknowledged to be based heavily on judgements, such as penalties. This may explain the failure to use VAR properly even in such cases.

A blatant mistake happened in the Liverpool versus Wolves match described above, where the referee whistled a Mané goal ‘void’ for the passing player’s handball whereas the TV replay made it clear that it had squarely hit the top the player’s shoulder and not touched the arm at all; no commentator could understand why VAR did not settle this in a few seconds (though it did settle it correctly in the end).

A more subtle example was the reversal of the referee’s ‘no-penalty’ decision at 20 minutes and 10 seconds into the game between Wolverhampton Wanderers and Manchester City on 27th December, 2019. A City player was contacted by a defending player in the penalty area and a fraction of a second later fell theatrically. The City player was not in a position to score but was well to side of the goal and nearing the touch line and the ball went out of play after the fall. The referee waved play on but the

³² <https://www.bbc.co.uk/news/education-41580550>

City players protested and VAR looked at the incident. A commentator remarked that it ‘looked theatrical ... there’s not enough in that’. The TV replay showed that the defender had momentarily stood on the attacker’s foot, but nothing that would lead one to expect the award of a penalty in the normal flow of the game and certainly nothing that comprised a blatant error on the part of the referee – on the contrary – see Figure 13.



Figure 13: Two successive frames from around 20 minutes and 10 seconds into the game between Wolverhampton Wanderers and Manchester City on 27th December, 2019. VAR overturned referee’s decision and awarded a penalty.

The VAR review continued for 2 minutes and 12 seconds. A commentator remarked ‘There are those who say if you have more than three replays and can’t decide you shouldn’t progress with the check’ and ‘If it takes more than a minute you shouldn’t go on’. A commentator remarked dismissively at the outcome: ‘Well there you go – you see an awful lot of that kind of contact in penalty boxes.’ The penalty was then taken and saved, the ball bouncing back off the goalkeeper and being kicked out of play by a defender. But VAR intervened again and decided that the penalty should be re-taken because of encroachment by a defending player into the penalty area at the moment the kick was taken. Figure 14 is the frame shown to TV viewers to justify the decision. As can be seen, there are five player encroaching, the one furthest forward, at the top of the

picture, being a City player but the half-time explanation by a referee was that the crucial infringement was that of the player's foot which is indicated here by an arrow. This is the foot of the player who would subsequently kick the ball out of play. In the traditional game this would never be clear enough to call for the penalty to be retaken.³³ A commentator remarked: '[The game] at this moment is being re-refereed rather than, merely, refereed.'



Figure 14: 'Penalty Encroachment' – 27 December, 2019, Wolverhampton Wanderers versus Manchester City (foot, arrowed, is on the line at the moment of the kick)

The retaken penalty was scored nearly 5 minutes after the referee's 'play-on' decision, the whole episode constituting, for many viewers, including many neutrals, not justice,

³³ Not to mention the fact that in this frame the ball is already on its way and a fiftieth of a second earlier the foot *might not* yet have landed on the line.

but the execution of a massive injustice. In no part of this incident did the on-field referee make a glaring error; in no case would viewers have felt a massive injustice had been done if the on-field decision was accepted.

The half-time commentary included the explanation by a referee, as quoted above, plus his justifications of this decision and the original decision to overturn the ‘no-penalty’ on-field judgement by citing precedents that had occurred in the VAR era – very much an indication of the establishment of a whole ‘accuracy’ culture rather than a culture of perceived justice, or support for on-field referees. It seems that the force of the idea that that VAR can ‘get it right’ is impossible to resist even in the traditional arena of judgements (where, traditionally, there has not even been a call for a piece of elastic to measure with).

The over-application of rules de-skills referees

Though this is speculative, the only way this author can make sense of the incident portrayed on the opening page of the paper and entitled ‘This Is Not a Penalty’ compared to the over-ruling of the referee and the granting of a penalty as described above is that not only is the culture being changed by the way that VAR has been implemented but that the referees who are using VAR are becoming de-skilled. VAR referees are becoming so used to looking for supposed certainty in their decision-making (and so fearful of being criticised for getting things wrong), that, like the proverbial centipede concentrating too hard on the movement of its legs, they are tripping over; the same applies to players, who concentrate too hard on coaching tips rather than internalising them and refereeing is itself a kind of sport. Referees, given the pressure to deliberate at length, are losing the

essential refereeing skill of making a quick judgement about something without exactly defined criteria. In live officiating the umpire or referee has to use their ‘somatic tacit knowledge’ to judge an almost instantaneous sequence of events that require processing as much at the unconscious level than at the conscious level.³⁴ It is a matter of having the experience and practice to grasp a situation as a whole, including in the case of handballs and penalties, the intentions of the various players including the ‘intuitive’ sense of the extent to which any putative offence is going to affect the game. This is something quite different to slowly assembling a decision out of a sequence of frozen moments. The sense of frustration is expressed by footballers, a manager, and a commentator after another VAR incident which ruled out a goal for an accidental handball – the result of applying a new rule too pedantically (as they saw it). This was the ruling out of a last-minute goal by West Ham in their match with Sheffield United on 10 January 2020 turning a draw into a defeat.³⁵ The [non] scorer of the goal remarked: ‘I’ve just watched it back. He has knocked the ball into my hand. If you are running with your arms like that with the rules as they are now it is handball, but it is not intentional. It is a kick in the teeth.’ The manager remarked: ‘it was ‘a really good goal ... Anybody who has played football or been around the game knows it was a good goal ... From my point of view, and the people who watch football, the decision is not right ... People who have played football know when it’s not right and tonight is one of those situations.’ Commentator Gary Neville, ex-Manchester United player, remarked that it was a law that he thought

³⁴ For the importance of tacit skills in skilled performances, see Dreyfus and Dreyfus, 1986. For the notion of ‘somatic tacit knowledge’, see Collins, 2010b

³⁵ The discussion can be found at <https://www.bbc.co.uk/sport/football/51071770>

‘[no] professional footballer current or former wants in the game’. He said ‘VAR is nothing to do with that goal. I am not defending VAR but it spots it and applies the rule of the game’.

But Neville is right about the decision but wrong about VAR: VAR is everything to do with exact application of laws replacing holistic decisions by referees. When they come to sit in the video referee’s chair, they no longer understanding that their job is not the pedantic application of rules but to help the referee where they have made a clear and obvious mistake in their holistic decision-making which will engender a sense of injustice in the crowd; instead they feel impelled to fall back on rules. Effectively, they nullify the the execution of footballing skills, and they nullify their own skills, by ‘working to rule’.

It is hard to correct cultural drift when it gets into peoples’ heads. There is, ironically, a technical solution! It is already used in a slightly different way in cricket. When players want to challenge an umpire’s decision and refer it to the off-field referee assisted by technological aids, they have a limited time – 15 seconds – in which to make up their mind whether to do it or not. In football the length of the review after the first replay is made available should be limited to 20 seconds. If it isn’t a glaring error, it won’t be obvious in this time and if it isn’t obvious VAR should not overrule the on-field decision. This way the cultural change back to a sensible use of VAR will be enforced.

Appendix 1: Summary of recommendations

1. Reconsider the nature of the referee’s job: it is about justice not accuracy.

Work out the consequences.

2. Get rid of the culture of concealment as a way of avoiding close examination of the procedures of VAR.
3. Install big screens at all stadiums where VAR will be used and return all authority to the on-field referee with assistance from replays displayed on these big screens.
4. Marginally redefine offside to mean ‘visibly offside without technical assistance in addition to replays, with benefit of the doubt being given to the attacking team’.³⁶ A further modification could be including the question of whether the potentially offside player was gaining any advantage in terms of scoring a goal. (Changing to Souness’s definition is compatible with this but without the changes in the previous sentence it would simply relocate the problem; the Souness change if adopted with or without the marginal changes suggested above would constitute a change in the rules that would change the game significantly since in some cases a player could gain advantage through offside without being penalised.)
5. Abandon the complex technology used by VAR for offside and abandon goal-line technology. Television replays and judgement are sufficient while being quick, transparent, and just. (This is a big change and will be resisted because companies have invested in these technologies. But the existing cameras and computers could be kept for use in replays and for informative summaries of

³⁶ Perhaps a widely spaced virtual grid could be superimposed on the replay.

performance, thus minimising the financial implications of this recommendation.)

6. Enforce the 'clear and obvious' rule by limiting judging time to 20 seconds once the replay has been addressed by the referee.

Appendix 2: The question of bias

The author is a Liverpool fan and many of the arguments presented concern Liverpool, who tend to be involved in or affected by the matches the author watches. Therefore, the arguments need to take account of possible confirmation bias. I have been acutely aware of the problem from the outset and have looked for, and found, examples where my criticism of the use of VAR would have disadvantaged Liverpool. For example, there was one case where I thought van Dyke was very lucky not to have interpreted as committing a foul in the penalty area and possible sent off, but it illustrates no principle in a clear way so I have not used it in the paper. The net effect of changing every off-side decision discussed in this paper in the direction argued for would have been to reduce Liverpool's lead in the Premiership by two points – this being the reversal of the offside given against Wolverhampton Wanderers in their match with Liverpool – everything else being equal, this match would have been a draw rather than a Liverpool win. On the other hand, the case of goal-line technology discussed in Figure 8, if reversed, would have meant Liverpool would have won the 2018-2019 Premiership by one point instead of losing it by the same margin.

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