

---

## ARTICLES

---

*Journal of the Philosophy of Sport*, 2010, 37, 135-146  
© 2010 Human Kinetics, Inc.

# The Philosophy of Umpiring and the Introduction of Decision-Aid Technology

Harry Collins

*I call 'em as they are*

*I call 'em as I see 'em*

*They ain't anything 'til I call them*

[Supposed baseball umpires' competing philosophies in respect of calling 'ball' or 'strike']

*Not only must Justice be done; it must also be seen to be done*

[From a landmark English court ruling of the 1920s]

Recently, technology has impacted upon sports umpiring and refereeing. One effect is that the means to make sound judgments has become 'distributed' to new groups of people such as TV viewers and commentators. The result is that justice on the sports field is often seen not to be done and the readiness to question umpires' decisions that once pertained only to the players and, in some sports, to the crowd, has spread to anyone who has a television. What is more, the questioning can now be done on good grounds. This change is explained and a way of thinking about it is put forward. The aim is to develop a theory of the relationship between human match officials and technology. Toward this end I offer a new terminology for the kinds of justice that are involved in match officiating. I argue that the introduction of new technology should be done in such a way as to maintain the justice of decisions and that justice is not the same as accuracy. Justice is best served with a restrained use of new technology.

## The Philosophy of Match-Officiating

I start with an abstract description of umpiring and refereeing. I introduce some new technical terms—two relevant to judging and four relevant to justice.

### Judging

*Ontological authority* is what baseball umpire Bill Klem, the source of the third quote in the epigraph, is claiming for himself; ontology is about what exists and he is saying he creates what exists in the way of balls and strikes.

---

The author <CollinsHM@cf.ac.uk> is with the Centre for the Study of Knowledge Expertise and Science (KES), School of Social Sciences, Cardiff University, Cardiff, UK.

*Epistemological privilege* can be understood via the remarks of the first two umpires: the first umpire is saying he is skilled at knowing how things are while the second umpire is implying that his knowledge of what happens is worthy of respect.<sup>1</sup> Both umpires are claiming a degree of epistemological privilege.

Using these terms we can explain the match official's job:<sup>2</sup>

1. *Ontological authority*: Umpires and referees are invested with a great deal of ontological authority. That is to say, in the normal way of things, what they decide *defines* what happened in any particular instance in so far as it affects the subsequent unfolding of the game, the outcome of the game and the way the game is recorded in the statistical archive. Thus, the rule in cricket and many other sports is 'the umpire's decision is final'. It is also illustrated by cricket and baseball commentators' advice in respect of disputed decisions 'look in tomorrow's newspaper'. What will be found in tomorrow's newspaper will have been created by the umpire.<sup>3</sup>
2. *Epistemological privilege*: To a large extent it is thought proper to grant ontological authority to match officials because it is assumed that they have the 'epistemological privilege' in respect of everyone else. Thus, if an umpire says 'I call it as I see it' it is assumed that the umpire is the most likely person to 'see it as it is'. This epistemological privilege has two sources.
  - 2a. *Superior view*: Umpires occupy positions on the field of play that provide a good view of the action. In some cases, these positions are defined in advance (e.g., tennis), in others, the referee is expected to follow play (e.g., soccer). In either case, the assumption is that umpires have a better view than most others.
  - 2b. *Specialist skills*: Professional umpires are usually ex-players, are given special training, and their decisions are continually scrutinized by professional bodies. Thus, umpires have specialist skills that are enhanced by the build up of scrutinised umpiring experience.

In the pretechnological era, these advantages, with the help of low-level technologies such as lines, nets, posts, and the bails on the cricket stumps, made ontological authority mesh smoothly with epistemological privilege and umpiring and refereeing worked well. New technologies, however, degrade the epistemological privilege of the umpire and referee. In some cases the epistemological privilege has moved to the crowd or the remote television viewer. This often means that there is disharmony between the ontological authority and the epistemological privilege leading to loss of credibility of the match official and the sport.

## Justice

*Presumptive justice* occurs when one has good reason to assume that justice could be seen to be done if only one was in a position to see it. For most of us this is how we live with ordinary criminal and civil justice: we understand the system well enough to assume that on the whole justice would be seen to be done if we were present at the court cases we only hear about or read about. In sport, traditionally, it was assumed that justice was being done as well as it could be done when the match official was exercising ontological authority. No one was better placed or

more capable of doing the job and it was reasonable to assume that if you were in the official's position you would make the same decisions. Presumptive justice worked pretty well in sport until new technologies came along.

*Transparent justice* means simply that justice is in fact seen to be done. This has always been possible in respect of some decisions since the crowd could see the net bulge when hit by the soccer ball and see the bail fall when the wicket was broken by the cricket ball. It has become more prevalent with television replays. Television has brought certain old instances of traditional presumptive justice into the realm of transparent justice.

*Transparent injustice* is the counterpart of transparent justice and needs no explanation. Transparent injustice rarely happened in traditional sport officiating but it happens frequently since TV replays have been introduced.

*False transparency* occurs where justice appears to be being done but it is not being done. In the early days of Stalinist show trials there was false transparency—it looked as though the accused were freely confessing to their crimes and justice was being seen to be done; later, when it was realized that the confessions were extracted by torture and threats these became cases of transparent *injustice*.

## **Changes in Epistemological Privilege and Their Effect on Justice**

We now examine the relationship between ontological authority and epistemological privilege as it applies to different groups—the players, the spectators, television viewers and commentators, ‘off-field’ match officials and technology. We trace the traditional relationships and the way these have changed as sports-decision technology has been introduced. Each new relationship can give rise to different kinds of justice.

### **The Players**

At the lowest level of games such as cricket, tennis, baseball, or soccer, there are no umpires or referees. It is almost certain that professional sports players begin their sporting experience in the absence of match officials. In these circumstances decisions are made by agreement among players. At a slightly higher level of sport an additional person is recruited to be the umpire or referee. In cricket, the umpire is chosen from the members of the batting team who are not batting at that time. In amateur soccer, referees and their assistants are typically provided by the teams taking part. It seems almost certain, therefore, that pretty-well every player of every sport has, to a greater or lesser extent, shared in the role of match official at some stage of their life. Because, from time-to-time, they will have had to make decisions that go against the interests of their teammates, they have learned that justice is central to umpiring and refereeing; they will also have learned in the course of the inevitable arguments, that it is good to be able to demonstrate that justice has been done as well as simply doing it.

Players involved in a game are, then, potentially pretty good umpires or referees in respect of both of the criteria labeled 2a and 2b. They are on the field and have a good vantage point, they have experience of the sport, and they have

experience of adjudicating. Therefore, quite outside the matter of partisanship, it is not surprising that they sometimes feel they have the right argue with the umpire or referee. Using the philosophical language, there is rough parity between the epistemological privilege of players and umpire even though ontological authority stays with the umpire; this can lead to some tension.<sup>4</sup> The extent to which players argue with match officials varies from sport to sport but referees are generally seen to ignore protests however vehement, as they must in order to retain their ontological authority.

## The Crowd

Traditionally, in respect of most decisions, the crowd seated at a sports ground is in a relatively poor viewing position. Traditionally, then, crowds' berating of referees was more a matter of partisanship than superior judgment—or if it was not, it could be seen to be so. The default assumption was that the members of a crowd were at an epistemological disadvantage compared with the match official.

## Television Viewers and Commentators

With the introduction of television, any crowd who benefits from replay screens located at the ground has lost its epistemological disadvantage in respect of a range of decisions. With multiple cameras being used, there is often at least one camera angle that provides a vantage point that is as good as, or better than, that of the umpire or referee. Replays, especially slow-motion replays, also put the television viewer, whether at home or at the match, in a still better position to make a judgment than the umpire or referee. Television replays destroy the 'superior view' advantage of umpires and, in many cases destroy the 'specialist skill' advantage since a good part of the specialist skill is to make the right decision in real time. In live officiating the umpire or referee has to judge an almost instantaneous sequence of events that require processing as much at the unconscious level than at the conscious level. This takes the experience and practice required to grasp a situation as a whole rather than to assemble a decision out of discrete observations.<sup>5</sup> If the time is slowed, and the event can be replayed, that part of the specialist umpiring and refereeing skill which comprises 'somatic tacit knowledge'—the embodied skills that go with the ability to appraise a rapidly unfolding situation in an instant—becomes redundant.<sup>6</sup>

Another specialist match officiating element is already widely distributed among that large class of viewers who know the rules of the game thoroughly, sometimes as a result of playing, and/or officiating themselves. Suddenly, then, a good proportion, probably the large majority, of television viewers are put in a position to make their own judgments not being in any way disadvantaged by factors 2a and 2b in the match official's list of supposed advantages that lead to epistemological privilege. What could once be done only by the exercise of specialist skills from a near-unique vantage point becomes a widely distributed ability, making judgments about what happened on the field becomes a ubiquitous expertise rather than a specialist expertise.<sup>7</sup>

Viewers have, then, in many instances attained at least epistemological parity with the umpire and players and sometimes have the epistemological privilege.

Television reveals that umpires occasionally make wrong decisions, sometimes glaringly wrong decisions, and yet the umpire still retains the ontological authority but with less obvious right to it. What was once presumptive justice has become degraded by occasions of transparent injustice.

Television, especially television replays, present, therefore, a dilemma for sport which has been handled in different ways. For a long time it was accepted that home viewers (and more latterly spectators at the live game who have a large television screen which offers the broadcast replays), might have a better ability to judge than the umpire but nothing was taken to follow from this: the location and process of decision making was not affected. This could be, and was, justified in the discourse of sports viewers and commentators by accepting that the umpire or referee could be 'unsighted'—the view obscured by other players—and/or that the job of making decisions in real time was a hard one. It was possible to accept that the locus of ontological authority should remain the same and made compatible with evident mistakes resulting from the shift of the epistemological privilege so long as the mistakes were easy to understand given the difficulty of the umpire's job. The role of the match official is sometimes *defined* as being to make reality in the course of play irrespective of what TV shows and match officials are banned from looking at replays. Sometimes replays are not shown on the ground only on broadcast television, giving the home spectator, and TV commentators, more epistemological privilege than anyone else but allowing the game to proceed smoothly because no-one on the field or in the ground knows what television is showing.<sup>8</sup>

### The Off-Field Umpire

The number of disputed decisions and the very obvious advantage of television replays has, however, brought about at least a partial change of attitude in some sports. Some have introduced television as an aid for match officials. This helps to justify the ontological authority of the umpire by restoring at least epistemological parity with TV viewers. Different sports have taken up this option to a greater or lesser extent and those that have taken it up use it for only some decisions. For example, it has never been used in soccer (see note 8) but it is regularly used for certain decisions in rugby football and for a growing subset of decisions in cricket. In these sports a newly created class of 'off-field' umpires and referees control and summarize the replay evidence.

An example of the successful introduction of the off-field referee is rugby football where it is used to decide if a try-scoring move has been completed legally. In rugby the on-field referee makes the final decision based on the advice received from the off-field referee with viewers watching the replays while the decision is being made and TV commentators almost always anticipating the outcome correctly. This system works well—in that justice is widely seen to have been done—so long as the off-field referee's judgments accord with the television viewers' judgments—each viewer now being their own expert adjudicator. Of course, these judgments should coincide given that replay-judging is close to a ubiquitous skill giving epistemological parity between TV viewer and off-field advisor. On the rare occasions when the two judgments do not match it is usually because the call is so marginal that either of two conflicting conclusions are 'reasonable' and only the most partisan viewers become badly upset.

## Reconstructed Track Devices (RTDs)

Television replays are just one kind of technological sports decision aid. One other very well-known kind of aid is what can be called a 'Reconstructed Track Device' (RTD). Perhaps the most well-known example of an RTD is 'Hawk-Eye', which is used in both cricket and tennis. RTDs use visible-light TV cameras to follow the path of the ball and a procedure to filter pixels in each frame. Certain pixels are taken to represent an indicator of the position of the center of the ball and certain others an indicator of the position of the line or of other features of the playing arena, between-frame consistency helping to extract significant pixels from background. The space and time coordinates of these pixels are represented numerically and a statistical algorithm reconstructs the flight and impact point of the ball and crucial features of the playing area by combining information about the pixels in the different frames with information about the size of the ball, the physics of its distortion (in the case of tennis), the width of the line (in tennis), and so forth. The output of the calculations can then be used to make an 'in/out' decision in tennis and to construct an image of the playing area and the flight of the ball using colors that give an appearance approximating to the real setting but with sharpened edges and idealised precision. In the case of tennis, information about the likely distortion of the ball upon bouncing can be used to estimate the size and shape of the contact footprint and the visually reconstructed bounce point can be elongated to represent the outcome of the calculation.

Every such system is, of course, subject to statistical uncertainty. However sharp the reconstructed images, they represent an 'estimate' which has errors, whether or not the error distribution is fully understood. The errors will affect the accuracy of the estimated bounce point, the reconstruction of the playing surface and lines, and the shape of the reconstructed footprint. Since its introduction, Hawk-Eye has been the subject of some debate about its accuracy to which an earlier paper coauthored by the present author made a contribution.<sup>9</sup>

The company responsible for the introduction of the device sometimes presents it in a way that makes it easy to believe it is accurate to a millimeter in tennis<sup>10</sup> but also claims that its 'average error' is 3.6mm.<sup>11</sup> Unfortunately, the graphical replays that simulate the flight of the ball and the bounce footprint, and that are shown to viewers on television, contain no information about errors nor any indication that they are subject to errors; they give the impression that the devices can make judgments with complete accuracy. That these replays are simulations giving a misleading impression of accuracy is, seemingly, not widely understood. Thus, David Gower, ex-captain of the English test-cricket team, and now commentator for Sky Sports, remarks:

It is worth noting, though, that the reason for those lines [i.e. the lines on the wicket that mark what we will refer to below as the 'zone of uncertainty'] is that we are not talking about the situation in tennis, for example, where Hawk-Eye is just tracking the ball and showing fact in graphic form. With an lbw referral, we have to acknowledge the element of computer-guided prediction as to where the ball would have ended up. That is an important difference.<sup>12</sup>

Gower is here comparing the use of Hawk-Eye in cricket and tennis. In cricket Hawk-Eye is used to estimate the trajectory of the ball after it has hit the batsman's pad. The 'leg-before-wicket' (lbw) rule requires that the umpire estimate whether the ball would have gone on to hit the wicket and nowadays RTD's are sometimes used to aid the decision when the players dispute it. Gower understands that this calculation of the continuing trajectory can only be an estimate but believes that, since the RTD can track the entire flight of the ball in tennis, there it is only a matter of 'showing fact in graphic form'. Gower is missing the point that the limited frame-speed of cameras and the high speed of the ball means that forward projection is also needed in tennis. He also misses the point that such things as the shape of the impact footprint of the ball is also an estimate as is the position of the edge of the line!<sup>13</sup> It may be that on average an RTD's estimate of the projected impact point on a cricket wicket is less accurate than its estimate of the relationship between line and bounce footprint of a tennis ball but these things are matters of degree.

Gower's quote also points to an important difference between the way Hawk-Eye is currently used in cricket and in tennis. In cricket, the potential inaccuracy of the reconstructed track is acknowledged by the presence of what one might call a 'zone of uncertainty'—which is about 55 mm wide—around the edge of the wicket. If the ball is shown to impact in that zone, the original umpire's decision stands. In our terminology, when players demand a review of an umpire's decision, ontological authority is effectively transferred to Hawk-Eye but only so long as the impact point of the ball is not within the zone of uncertainty. If the impact point is within the zone of uncertainty, ontological authority stays with the umpire and *presumptive* justice is done—it is assumed that no-one and no-thing could do better than the umpire. In tennis there is no zone of uncertainty: whenever a player demands a review, ontological authority is shifted to Hawk-Eye and its decision over-rules any doubts that players or even umpire may have.

### Why Is It Wrong to Transfer Ontological Authority to RTDs in Tennis?

We know that an RTD like Hawk-Eye, with, in tennis, a 3.6mm average accuracy, is likely to give the wrong call on a proportion of occasions where the call is close. Nevertheless, since it seems unlikely that human umpires could do any better, and they might well do worse, why not simply take Hawk-Eye's output to be the *definition* of in and out? Even if for very close calls the decision was near random, it might not necessarily be any more random than the outcome of human perception. Furthermore, as time goes on it seems probable that RTDs will become more accurate and it could be argued that there should come a time when justice would be best served by their taking over from umpires even if it is not best served now.

As Hawk-Eye is now used in tennis, however, it creates *false transparency*. When the crowd and television viewers see the reconstructed flight of the ball, the reconstructed lines and the reconstructed impact footprint, they are all too easily led to believe, in Gower's terms, that they are seeing 'fact in graphic form'. They believe they are being shown that a ball was definitely 'in' or 'out' with no error.

False transparency is bad in itself; it must be bad to encourage millions of people to believe they are seeing a kind of justice being done which is not being done.

However accurate the machines become there will always be zone of indeterminacy. We simply do not know what 'in' and 'out' means when the ball is close to the line. Tennis lines cannot be drawn exactly straight or exactly accurately—most obviously on a grass court—and they are likely to spread a little as a game goes on. We do not know what defines the edge of a tennis ball given that it is a furry object—the edge is not clearly defined. We do not know if the impact footprint is the appropriate datum or if the balls 'shadow' when illuminated from above is the right datum—i.e., if the ball bounces vertically from a low height is it in or out if part of it overlaps the line but is not in physical contact with the line. The human eye would perceive it as 'in'—an optimally accurate machine working with impact footprint would indicate 'out'. Given that in such cases, other things being equal, the ball has traditionally been counted as 'in', do we now want to change it to 'out'. Furthermore, we know that in the case of a fast low shot a ball that has an impact footprint that touches the outer edge of a line and is 'in' by that definition, may roll and skid such that it bounces up from a point behind the line and will almost certainly appear to the human eye to be 'out'. Given that in such cases, other things being equal, the ball has traditionally been counted as 'out', do we now want to change it to 'in'. These changes would mark a sharp departure from the traditional nontechnically assisted game that is played everywhere except at national tournaments.

*False transparency* is not only a bad thing in itself: its becoming acceptable in respect of such new technologies could have damaging long-term consequences. The day is arriving when computer-generated television images will be indistinguishable from real-time television photography and, unless the public is well-trained and vigilant, this could put the ability to create what appears to be truth into the hands of the powerful. A widespread false understanding of the capabilities of technology—it being thought capable of greater accuracy than it actually is—has equally worrisome consequences.<sup>14</sup>

The crucial philosophical consideration is an adjustment in our understanding of the point of sports decision aids in the light of the philosophy of match umpiring and refereeing that has been developed above. Match officiating is not about accuracy it is about justice. Accuracy and justice are not necessarily the same. For example, where an optimally skilled and perceptive umpire would consistently call the ball one way and an optimally accurate machine based on impact footprint would call it another, it is not at all clear that machine provides the appropriate call. Coherence with tradition and the way the nontechnically assisted game is played may be more important so long as there is equity for all players. Even where umpires are inconsistent on close calls, *presumptive justice* is perfectly satisfactory in sport—the human umpire can deliver *presumptive justice*, as they always have, so long as no spectator or television viewer can do it better. Zones of uncertainty would make it clear when and where nothing could *be sure to do better* than the human umpire. The ontological authority should, then, stay with the match official in these circumstances.

Transparent injustice must also be avoided. Where new technologies, that do not turn on false transparency, make it abundantly clear that a human judge is delivering injustice, then ontological authority should revert to the machine. That



is, the machine should have ontological authority outside the zone of uncertainty but only outside the zone of uncertainty.

## Conclusion

Umpiring and refereeing are about justice not accuracy. Justice has been divided into four kinds. In umpiring and refereeing, transparent injustice must be avoided and falsely transparent justice must be shunned. Technologically assisted umpiring and refereeing should work with a combination of presumptive justice where the ontological authority remains with the umpire and transparent justice where the ontological authority is transferred to the machine. The dividing line is between close calls and obvious mistakes. In sum, technology should be used to avoid errors which are obvious to all; human judgment should be used where there are no obvious errors. Technology should not be used to make new kinds of judgment. As explained, to accomplish this, responsibility for organizing the decision is often best shared between the on-field official, an off-field official and the technological aid. There are eight major points made in this paper.

1. Ontological authority has traditionally been in harmony with epistemological privilege but umpires' and referees' epistemological privilege is no longer unique as television and other sports decision aids have allowed viewers and spectators to have an equal, and in some cases, better view of events on the field of play. Presumptive justice no longer holds.
2. This does not matter where parties of equal epistemological status agree about the correct decision as the ontological authority of the umpire is confirmed by the widespread witnessing of their 'good judgment' and presumptive justice can be replaced by transparent justice.
3. It also should not matter in the case of disagreements over marginal decisions where neutral observers would agree that either decision would have been reasonable. In these cases, strong objections are based more on evident partisanship and presumptive justice can still be accepted.
4. Where the distribution of epistemological privilege does matter, however, are those cases where television and other technologies show that an obvious mistake has been made. In these cases the ontological authority of match officials is inevitably undermined by the transparent injustice.
5. Where match officials are undermined, their epistemological privilege can be restored by allowing them access to the same information as spectators; that is to restore epistemological parity. At the moment this is usually done via an off-field official.
6. Some sports decision aids can be less accurate than they appear, leading to false transparency that should be avoided.
7. They can also give the false impression that accuracy is the cornerstone of justice in match officiating whereas exact accuracy is meaningless and is not necessarily a desirable goal.
8. A zone of uncertainty in all cases of the use of sports decision aids would resolve the problems.

Finally, in the case of the argument to come over wrong adjudications in the 2010 soccer World Cup it will be important to understand the role of technology. It will be especially important to disentangle the question of exactness and the question of justice. In the increasingly heated discussion about the introduction of ‘goal-line technology’ the two are often confounded. To get rid of transparent injustice all that is necessary is to give referees direct or indirect access to the television replays that the viewer sees and allow them to use these in their decision-making so as to avoid obvious mistakes. There is no need to try to find technology that will define the ‘exact’ position of the ball. In rare cases television replays will not be able to determine whether the whole of the ball crossed the line or not—advanced technology could resolve some but not all of such cases but there is no need for it. In such cases, humans, using TV replays, can be seen to be doing their best, especially if backed up with a ‘benefit of the doubt’ rule such as, ‘if in irresolvable doubt, it is a goal’. In such circumstances the transparent justice and presumptive justice needed by sport will have been achieved without invoking the false idol of error-free measurement and its counterpart, false transparency.

## Notes

1. Baseball calling is a particularly rich source of philosophical musing because the strike zone is so abstract. There are no markings and it is defined in space in relationship to the dimensions of the batter. Its upper bound has moved very considerably over the years as a result of changing fashions among umpires and the demand from fans for more hits and fewer ‘outs’. Although only the third sentiment was uttered by a real umpire, the first and second utterances reflect what umpires often say but not necessarily in these words.
2. At the top level umpires are chosen to be neutral; that observation aside, the question of umpiring integrity or partiality does not feature in the analysis pursued here. See (7) for an argument that says umpires who are partial or without competence are not really making judgments at all. This aspect does not concern us: here all umpires are assumed to be doing their best and, except where specifically mentioned, are taken to have levels of competence appropriate to their calling.
3. This point and these illustrations can also be found in (7). Russell analyses the role of umpires into a performative (ontological authority) aspect and an observational (epistemological) aspect using the language of the philosopher Austin but he is not concerned with the tension between them except as a problem for providing a coherent philosophical account of the umpire’s job.
4. This is not the case for every feature of the match official’s role. For instance, in sports like soccer and rugby the match official is charged with balancing pedantry with the need to ‘keep the game going’. The match official is nearly always better placed to make such decisions.
5. As Dreyfus and Dreyfus (5) correctly argue, many skills are much better exercised without self-conscious processing and many require the grasp of the whole situation.
6. Somatic tacit knowledge is like the skill required for balancing on a bicycle, to refer back to Polanyi’s famous but confounded example. It is also what is needed for the physical aspect of playing a sport—it is located in the build up of patterns in body and ‘mind’. For a more complete discussion of somatic tacit knowledge, and a clarification of the bicycle-riding example, see (1).

7. For analysis of the nature of expertise, and the idea of ‘ubiquitous and specialist skills’ see (3). For readers of the science and technology studies literature we should explain that this paper explores a region in which many ordinary people either possess, or have been granted through the development of certain technologies, the ability to make sound judgments in areas which were once the prerogative of the specialist alone. This paper should make it still easier to see the difference between those who can and those who cannot legitimately contribute to ‘technical phase’ of a decision.

8. This seems an extraordinarily misguided solution as it can only encourage viewers to stay at home and watch the better view that they have on TV. There is still less incentive to travel and pay a great deal to be at the match if one also suffers the indignity of having vital information about what is going on withheld. On the other hand, showing TV replays at the ground can violate everyone’s sense of justice if TV is not used as part of the adjudicating process. Recent incidents include, on 2 June 2010, the spoiling of Detroit Tigers’ baseball pitcher, Armando Galarraga’s, perfect game (it would have been only the 21st ever at this level) by an incorrect call, obvious to TV viewers. The umpire admitted “I just cost that kid a perfect game.” On Sunday 27 June 2010, during the soccer World Cup, England’s second goal against Germany was incorrectly disallowed, television showing clearly that the ball had crossed the line by around two feet before bouncing out of the goal while later in the same day Argentina’s first goal against Mexico was revealed to be clearly ‘offside’ by a replay shown at the ground—not a difficult decision about a player’s position but, seemingly, a momentary misinterpretation of the journey taken by the ball on its way to the goal. The match officials consulted in the light of the replay but realized that there was no mechanism to change the clearly unjust decision and the goal had to be awarded. In these cases the match officials did not want the ontological authority that was forced upon them.

9. See (2)—see also [www.cf.ac.uk/socsi/expertise](http://www.cf.ac.uk/socsi/expertise).

10. Or, more exactly, that though it is ‘unable to prove conclusively that the ball was 1mm IN as shown by Hawk-Eye, it can show that 1mm IN is a likely’ See: [http://www.hawkeyeinnovations.co.uk/UserFiles/File/Hawk-Eye%20Line%20call%20explained\\_Final.pdf](http://www.hawkeyeinnovations.co.uk/UserFiles/File/Hawk-Eye%20Line%20call%20explained_Final.pdf) [accessed 22 January 2010]. Dr Hawkins, the founder of Hawk-Eye Innovations, suggests that the reliability of the device would certainly be in the high 90s (90% accurate) even for balls this close (1mm) to the line (<http://www.cf.ac.uk/socsi/contactsandpeople/harrycollins/expertise-project/Hawkeye-reply-to-open-letter.doc>). Given that he also says the *average* accuracy of the device is 3.6mm, see below, and that it is hard to know what 1mm accuracy means, see below, extra information seems to be needed to reconcile the two figures.

11. See [http://www.hawkeyeinnovations.co.uk/?page\\_id=1011](http://www.hawkeyeinnovations.co.uk/?page_id=1011). The figure comes from a test conducted in 2006.

12. Gower is quoted in *The Sunday Times* Newspaper (6)

13. To be fair to Gower, Collins has discovered that it was not obvious even to experienced research physicists that RTD’s produced an estimate based on mathematical modeling and statistical procedures until it he pointed it out.

14. See, for example, the debate over the accuracy of the Patriot antimissile missile in (4).

## Acknowledgments

I am grateful to Robert Evans, with whom I discussed the ideas at great length and who is responsible for significant modifications to the paper, and to the members of the Cardiff, KES, seminar group, whose remarks results in substantial improvements to the final draft.

## References

1. Collins, H.M. *Tacit and Explicit Knowledge*. Chicago: The University of Chicago Press, 2010.
2. Collins, H.M., and Evans, R.J. "You Cannot be Serious! Public Understanding of Technology with Special Reference to "Hawk-Eye":" *Public Understanding of Science (Bristol, England)*, 17(3), 2008, 283–308.
3. Collins, H.M., and Evans, R.J. *Rethinking Expertise*. Chicago: The University of Chicago Press, 2007.
4. Collins, H.M., and Pinch, T.J. *The Golem at Large: What You Should Know About Technology*. Cambridge, New York: Cambridge University Press, 1998.
5. Dreyfus, H.L., and Dreyfus, S.E. *Mind Over Machine: The Power of Human Intuition and Expertise in the Era of the Computer*. New York: Free Press, 1986.
6. Gower, D. "Third umpire strikes back as review system improves." *The Sunday Times*. (20 December 2009). Available online at: [http://www.timesonline.co.uk/tol/sport/columnists/david\\_gower/article6962837.ece](http://www.timesonline.co.uk/tol/sport/columnists/david_gower/article6962837.ece) [Accessed 7 April 2010]
7. Russell, J.S. "The Concept of a Call in Baseball." *Journal of the Philosophy of Sport*, XXIV, 1997, 21–37.