Note to WeRobot readers: Thanks for reading our paper! This is an early draft, and we are really looking forward to your feedback as we continue to develop it. Though we’re open to comments of all kinds, we’re particularly interested in suggestions about how we ought to frame/pitch this paper: is it primarily a series of case studies to examine automation in particular contexts? Should we focus more explicitly on applications to particular areas of policy or law? Are there other dimensions you think we’re missing? Thanks in advance for your help! — Meg + Karen

Sporting Chances: Robot Referees and the Automation of Enforcement

Meg Jones and Karen Levy

Introduction

In Major League Baseball, the strike zone—the volume of space over home plate, between the midpoint of the batter’s torso and his knees—seems to be well-suited for automation. Automated enforcement of the strike zone (that is, evaluation of whether pitches are balls or strikes) has been technologically and economically feasible for years. In fact, at-home spectators are aided by the “box,” a visual representation of the strike zone, and ballparks are equipped with cameras that are used to evaluate umpires’ long-run accuracy.

Yet umpires are still human, at least for now. Despite statistical evidence about their greater error rate, and the availability of an automated and precise enforcement system, the MLB—backed by its fans—has opted to retain human decisionmakers as arbiters of the rules.

This paper examines controversies about automated enforcement technologies in professional sports. Sports offer unmined insight to discussions about automation and law, and merit serious inquiry by academics interested in these issues. The sports field is a contained legal world, in which the rules of play are explicit and endlessly discussed, and their implementation routinely contested. Consistent, impartial enforcement is ostensibly paramount for fair play. Thus, we might view the sports field as a legal microcosm, and the controversies that arise related to automation here might inform our understanding of broader scenarios. As journalist David Leonhardt put it on Twitter recently: “[i]n the future, we will wonder why Americans once allowed fallible human beings to drive so many vehicles and make so many ball-strike calls.”

As the strike zone illustrates, sports might seem like clear contexts for “perfect” automated enforcement, of the sort discussed and debated by legal scholars. Robot refs are well within reach technologically—in fact, they are often used for unofficial purposes, like fan

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1 https://twitter.com/DLeonhardt/status/783860523653799936
2 Zittrain, Christina Mulligan, Michael Rich
engagement and team analytics. And robot refs have some visible supporters: NBA MVP Steph Curry said at TechCrunch last year that he “would love” if robots replaced fallible human referees, joking that “I would have to throw my mouthpiece at those new inventions!”³—a reference to his frustrated reaction upon a (human) ref’s determination that Curry had fouled out of Game 6 in the 2016 NBA Finals. Others point to robots as the best route to accurate enforcement of rules. FIFA, which is in the process of testing a video assistant referee (VAR) system to assist on-field officials, has suggested (via its chief of technical development Marco van Basten) that such a system will make the sport “more honest ... that is all we want to achieve[, for] the result to be the best one, the right decision.”⁴

Moreover, there is ample evidence of human officials’ fallibility and bias. A 2016 article in Economic Inquiry, for example, demonstrated that NFL officials are more likely to call penalties on a team when they are positioned closer to the opposing team’s sideline bench, where coaches and players sit—suggesting that referees are influenced by nearby verbal pressures (i.e., coaches screaming at referees to call a penalty).⁵ Other research has shown that factors such as crowd noise,⁶ player status,⁷ conference membership,⁸ and player/referee race differences⁹ systematically bias referees’ in-game judgments.

In a few sports, automated rule enforcement is very much the norm, and relatively noncontroversial. In running, athletes commonly wear timing chips that interact digitally with timing mats along the course (typically via RFID) and at the conclusion of the race.¹⁰ In swimming, in which races are determined by hundredths of seconds and it can be impossible to visually detect who finishes first, sensors embedded in the wall of a pool are used to accurately measure race times. In fact, the precision of timing systems is constrained not by the timing technology, but by variation in the length of the swimming pool: FINA, the international swimming federation, limits timing precision to the hundredth of a second not because of the capabilities of timing systems (which can measure to the millionth of a second) but because pool dimension regulations permit variation by up to three centimeters per lane, a tolerance required by the physics of pool construction.¹¹

But in many other contexts, automated officiating systems have faced strong resistance as substitutes for human judgment. Why? Perhaps justifications are sentimental: heartstrings and custom win out over efficiency. Or ontological: the game just wouldn’t be what it is were it

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⁴ http://www.mirror.co.uk/sport/football/news/fifa-chief-marco-van-basten-9259448
⁶ Buraimo Forrest Simmons 2010
⁷ Mills social pressure at the plate 2013
¹¹ Of course, both running and swimming share the distinction of requiring only one ultimate measurement—who reaches a point first—and that measurement is of fundamental import, as opposed to a game like basketball, baseball, or football, in which there may be hundreds of judgment calls to be made per game. http://deadspin.com/this-is-why-there-are-so-many-ties-in-swimming-1785234795
officiated by robots rather than people. Or based on a notion of propriety and integrity: using instant replay may disrupt the gentility of sports like golf, consider the “gentleman’s game” (in which players traditionally call their own penalties). These sorts of sociocultural factors tend to be undertheorized in emerging contexts of automation, and we might look to sports to help us recognize them.

Another oft-cited justification for limiting the role of robot refs presents a puzzle. Technological fallibility tends not to be much of a rallying cry in these debates; rather, there is general acquiescence to the fact that automation would very likely bring on-field officiating into closer alignment with the rulebook. Yet, the probability of more consistent enforcement seems itself to be a justification for limiting the role of automation in this context. This is puzzling, as consistency and predictability are powerful motivators for automation in non-sports contexts—and these features seem prima facie to be the principles of good officiating. We suggest that the reason consistency plays this paradoxical role is the preservation of beneficial unpredictability—or, in context-appropriate terms, the “sporting chance.” Part of what makes sports compelling is the debate over contentious calls: these adjudications compel fans to engage in a facet of the game from which they might be excluded were enforcement automated. The potential for human fallibility creates a layer of drama that keeps fans watching (and, not incidentally, advertisers paying).

We survey these debates across a range of sports: football, golf, tennis, and baseball. We look closely at automation and augmentation of human referees, and the role of instant replay technologies in providing technological accounts that justify or contradict on-field determinations. We consider what sports and types of rules are most likely to be automated, why, and how. Finally, we explore how debates about robot refs in sports can further more complex, nuanced conversations in robotics policy, and in the automation of rule enforcement more generally.

Sports offer unparalleled insight into public understandings of, and attitudes about, automation. While members of the public may have limited visibility into the risks and virtues of, say, algorithmic risk modeling, many people have strong opinions about the deployment of a robot line judge in a tennis match. Indeed, people do some of their most explicit, informed thinking about rules and technologies in sports contexts. If we want to know how public attitudes about automation develop and what factors might impact them, we ought to look, as so many Americans do, to sports.

I. “After Further Review...”: Football

On December 7, 1963, college football fans, who had waited a week for a football game that had been rescheduled in the wake of the Kennedy assassination, saw and then resaw Army quarterback Rollie Stichweh run in a touchdown from the one yard line. Fans of the biggest game in the sport (the first Super Bowl would not be another four years) later asked Stichweh about how he scored twice in a row, even though the announcer Lindsey Nelson advised viewers
“Ladies and gentlemen, Army did not score again!” By the time it was used in the first National Football League championship in 1967, instant replay had become commonplace.

American football is a rugby spin-off developed in the late 19th century. Post-Civil War, post-American Frontier, football was born to combat the feminization of young college men who would not see military or survival hardship, part of a “cult of masculinity.”12 Brutality has always been an important, central aspect of football, as have military precision, strategy, and discipline. Because of this celebrated brutality and because of a tradition of rule-bending (all is fair in love and war), American football had referees from its inception.13 At the beginning of professional football in the 1930s, referees were undertrained and only loosely supervised, maintaining minimal order for the sluggish, rough-and-tumble sport. Then Hugh “Shorty” Ray came onboard and revamped the system, as he had done with high school football. The expansive “play situation book” he wrote, which attempts to prepare the officials for every scenario, is still used today.14 But today, officiating teams prepare for every scenario by having eyes everywhere—almost everywhere.

Football is a relatively new sport and considered quintessentially “American.” As an institution, the sport is very willing to progress and constantly being reinvented, which means it is open to the integration of new technology. Football is wildly popular (three times more popular than the next most popular sport) and has dominated television ratings for decades.15 Instant replay was an important part of its success, because it was so difficult to see everything that was happening on such a big field with so many players, and additional footage was perfect for holding the audience’s attention between plays. The technology changed how fans watch football, what they expect to see, and how they expect to engage with the players and referees. Noted communication theorist Marshall McLuhan was so enamored of the effect he used the term of the “Age of Instant Replay” and wrote, “Until the advent of the instant replay, televised football had served simply as a substitute for physically attending the game; the advent of instant replay—which is possible only with the television—marks a post-convergent moment in the medium of television.”16 And, legendary broadcaster Dick Enberg said, “Replay completely changed how we all look at sports. I mean, people go to a game and they turn to each other and they go: ‘Gee, I wish I was home. I would love to see that play again.’”17

13 Sally Jenkins, The Real All Americans 105 (2008) (This is unlike British football, which initially was called by the players themselves.).
14 http://operations.nfl.com/the-officials/history-of-the-official/
17 http://www.denverpost.com/2013/11/16/how-instant-replay-has-revolutioned-sports-on-tv/
But instant replay also changed the rules. Just because a viewer sees a play numerous times from various angles, does not necessarily mean a referee must have access to the same insights. The NFL explains:

Throughout the history of the NFL, the custodians of the game not only have protected its integrity, but also have revised its playing rules to make the contests fairer, safer and more entertaining. Time and again, the league has shown that it is open to ideas generated by any source or circumstance — or even by new technology — if it believes that the changes will improve the game.¹⁸

Initially, an official watched the same broadcast seen by viewers at home and could reverse a call that was “totally conclusive,” but any replay decision had to be made within 15 to 20 seconds. In reality, play was stopped so often and for so long that the NFL owners decided to omit replay calls in 1992. By 1999, however, they were reinstated through a challenge system wherein each head coach is given two challenges throughout the game (three if they win the first two challenges).

![Diagram](image-url)

Fig. To help describe what can be a mysterious structure, the NFL has a page dedicated to the instant replay process.

Calls are also video-reviewed by a replay official after the two-minute warning at the end of each half, and for all scoring plays and turnovers. These rules are established by the Competition Committee that proposes changes to the NFL owners who vote to make the final decision.

Anyone who watches football is braced for the lengthy reviews that accompany questions about whether a ball has crossed the plane dividing the field from the inzone. In 2015, New England Patriots coach Bill Belichick pushed the NFL to install permanent cameras on the goal lines and sidelines. After studying the issue, the NFL declined the request due to costs.\textsuperscript{19} This seems like a strange response from a league that brings in more than $12 billion of revenue a year. It is likely no obvious sponsors were found to support such a techno-regulatory change. In 2014, a $400 million sponsorship deal with Microsoft was struck to supply custom Surface Pro Tablets on the sidelines; sideline computers on gameday had been banned to that point.\textsuperscript{20} Additionally, it is not clear that cameras on the goal lines would be effective. Used in English Premier League soccer, the Hawk-Eye system (discussed more thoroughly below) was invented by Brit Paul Hawkins, who explained why he thought fans, players, and coaches liked the system, saying, “That comes from the fact that there is no human element. It is based on automatic tracking, as soon as the ball goes over the plane the signal is sent... There are no subjective decisions.”\textsuperscript{21} He goes onto explain its potential benefit to American football: “The system is millimeter accurate, which ensures that no broadcast replays could disprove the decision. The system accuracy is not affected by any variances in the painting of the goal line or if the posts are not perfectly vertical.”\textsuperscript{22} That was back in 2013; in 2015, Hawk-Eye admitted that the number of players surrounding the ball at the goal line would significantly inhibit its utility, because the system requires a view of at least twenty-five percent of the ball throughout the play.\textsuperscript{23}

One of the most bizarre occurrences during a football game is when two sticks connected by a chain are carried by humans running onto the field to determine whether the ball has reached the first down line. It is time-consuming and clearly flawed. Inventors have been trying to improve the system since at least 1955, when Louis Peresenyi invented his “football yardage telescope.”\textsuperscript{24} In 1970, a news article described George Dicker’s invention—the Dickerod, which was simply an aluminum rod measured to ten yards and manned by a single person—as considerably safer than the chains, because the operator could just run away when plays came his way whereas the chain gang always dropped their sticks, tangling up players in the chain.\textsuperscript{25} The Dickerod is not an automated technology, but one skeptic, the Commissioner of the California Collegiate Athletic Association, argued relevantly, “What happens when the public misses the

\begin{thebibliography}{99}
\bibitem{19} http://www.espn.com/blog/nflnation/post/_fid/165835/inside-slant-bill-belichicks-replay-camera-proposal-more-complex-than-it-seems
\bibitem{20} http://www.espn.com/blog/nflnation/post/_fid/152562/inside-slant-microsoft-surface-tablets-penetrate-nfls-technology-barrier
\bibitem{21} http://sports.yahoo.com/news/nfl-nfl-open-to-goal-line-technology-195308382.html
\bibitem{22} http://sports.yahoo.com/news/nfl-nfl-open-to-goal-line-technology-195308382.html
\bibitem{23} http://www.businessinsider.com/why-nfl-uses-chains-2016-1
\bibitem{24} http://www.espn.com/blog/nflnation/post/_fid/187846/nfl-couldnt-improve-goal-line-technology-much-even-if-it-wanted-to
\end{thebibliography}
drama of the chain measurement?"26 Today, viewers at home see the first down line drawn for them on the screen during every play. In fact, it is not the accuracy of the chains that is the issue but the accuracy of the officials placing the ball in the original spot from where it is to be measured. In order to avoid delays, referees have simply made it a practice to place the ball on one of the yard markers on the field to designate where the next series of four downs will begin so there is no need for chain measurements. Still, at a certain point, someone demands or needs ten yards to be measured on the field, and it is reportedly for the drama and tradition that the chains continue to be run onto the field. The NFL explains:

Theoretically, the NFL also could use technology to get rid of the first-down markers and chains used to measure for first downs. A beam across the field could do the trick — but for that to work in many of the proposed systems, the football would need to contain a microchip — and any change to the ball is a big deal... The NFL has tested chips in balls and is not likely to add one permanently until quarterbacks are unable to tell the difference between a ball with a microchip and one without. And even if the chip is eventually adopted, the measuring chains may remain — since taking time for the measurements provides a break in the action that some coaches and players prefer. The measurements often add drama to the game — the anticipation and the tension building as the officials stretch out the chains.27

Football’s traditional brutality and associated popularity are threatened by new tragic revelations about the ramifications of its violent nature. One in three NFL players suffer some kind of brain trauma in his lifetime; some players experience dozens of concussions over the course of their careers; mental illness, substance abuse, and crippling degenerative conditions have been found in a large number of former players. These findings, detailed human interest stories, and lawsuits have “led to a perception that professional football is the Big Tobacco of sports, a profit-obsessed corporate entity with a callous lack of concern for the human beings who take the big hits.”28 Everyone knows football is dangerous, but there is a new wave of pressure on the sport to be more open about the nature of the dangers and to make it safer. Since the mid-1980s rule changes have been made to protect players. In 2013 new rules prohibited any player on offense or defense from creating forcible contact with the crown of the helmet by offensive or defensive players, outside the tackle box,29 and 2016 banned all chop blocks.30 Helmets come with the disclaimer that reads, “No helmet can protect you from serious brain

29 http://operations.nfl.com/football-ops/nfl-ops-honoring-the-game/health-safety-rules-changes/ (The tackle box is an area that extends from tackle to tackle, three yards beyond the line of scrimmage, and back to the offensive end line. The rule does not apply within this area.)
30 A chop block occurs “when an offensive player blocks a defensive player in the thigh or below while that same defensive player is engaged by a second offensive player above the waist.” http://operations.nfl.com/the-rules/nfl-video-rulebook/chop-block/
and/or neck injuries including paralysis or death. To avoid these risks, do not engage in the sport of football.  

The combination of rule changes and technology is where football sees hope. In 2016, the NFL announced its $60 million “Play Smart. Play Safe.” initiative, including the HeadHealthTECH Challenge to find innovative solutions to safety issues in the sport. From using robots for practice to smart mouthguards, football is looking for the right combination of tracking technologies to change the game again.

This may lead to a paradigm shift in officiating as well. Because so many players make the game hard to visually analyze or reconstruct, ball tracking technology may be the future of digital enforcement. Instead of having so many cameras trying to capture so many elements of the sport, placing sensors on those elements may be the obvious next step. Products like the Wilson X Connected Football tracks velocity, spin, and distance, and can already be purchased for less than $200. However, it is not obvious that these types of digital enforcement will be able to maintain the same type of drama generated by the camera visuals: long delays, repeated and indeterminate imagery, and fan scrutiny.

II. The Thinking Man’s Game: Baseball

In Major League Baseball’s official rules, the strike zone is defined as “that area over home plate the upper limit of which is a horizontal line at the midpoint between the top of the shoulders and the top of the uniform pants, and the lower level is a line at the hollow beneath the kneecap. The Strike Zone shall be determined from the batter's stance as the batter is prepared to swing at a pitched ball.” If the pitched ball passes through this three-dimensional area, it is counted as a strike; if not, it is called a ball.

32 http://www.newyorker.com/magazine/2017/01/09/can-technology-make-football-safer
33 https://www.fitguard.me/
34 The tracking technology would then be used to give the NFL Injury Report Policy, plagued by secrecy of players and teams alike, more accuracy and transparency. http://operations.nfl.com/media/2235/06-07-16-2016-injury-report-policy.pdf; http://www.newyorker.com/news/sporting-scene/how-to-save-football
35 http://mlb.mlb.com/mlb/official_info/umpires/rules_interest.jsp
QuesTec’s Umpire Information System was rolled out into several major league ballparks in the early 2000s. The system used four video cameras, positioned at different points in the field, to track the location and speed of the baseball during each pitch, and to determine if the ball should be considered a ball or strike. The system’s margin of error, in 2003, was touted as being 0.4 inches.

Importantly, QuesTec’s role was neither to replace the human umpire’s role in calling balls and strikes, nor to give umpires real-time data on which to base those calls. Rather, QuesTec was conceived as an evaluation technology: in stadiums that had QuesTec installed, umpires’ calls were assessed against QuesTec’s calls, and used to measure the performance of human umps (evaluations used to make promotions and post-season assignments). A 10% differential between the human umpire’s calls and the QuesTec system would lead to an ump’s performance being considered substandard.

Umpires, for their part, objected strenuously to the use of QuesTec, as did some players. Most visibly, in 2003, (then-)Arizona Diamondbacks pitcher Curt Schilling smashed one of the QuesTec cameras with a bat, allegedly because the home plate umpire had told him that the machine wouldn’t let him call Schilling’s pitches as strikes. The same year, the World Umpires Association filed a grievance with the National Labor Relations Board seeking to have the systems removed, based on concerns about their accuracy and variability; the dispute was ended in subsequent contract negotiations.

QuesTec was succeeded by a more accurate camera-based system called Zone Evaluation (Z.E.), and then by Sportvision’s similar PITCHf/x camera technology, which was first used in the 2006 playoffs, and has been in use in all major league ballparks since 2008. A PITCHf/x operator calibrates the system and records the top and bottom of the strike zone for each batter (since the placement of the zone is height-dependent) during the game.

Like QuesTec and Z.E. before it, PITCHf/x is used for umpire evaluation purposes. MLB personnel touted the system’s data as allowing for umpires’ performance improvement and coaching. As the MLB’s vice president for umpiring, Mike Port, put it in 2009: “The umpires, they don’t want to miss a pitch any more than a batter wants to strike out. Where the Z.E. system will give us a lot of help is more data to help identify any trends: ‘The last three plate jobs, you missed seven pitches that were down and in. Here’s how one of the supervisors can help you adjust your head angle or your stance to have a better chance of getting those pitches.’” After

40 http://baseball.physics.illinois.edu/FastPFXGuide.pdf  
41 Some have discussed using PITCHf/x data as a real-time decision aid for umpires rather than an after-the-fact evaluator, perhaps through a heads-up display or pocket-worn buzzer. http://grantland.com/features/ben-lindbergh-possibility-machines-replacing-umpires/  
the first year of Z.E. usage, three senior MLB umpires lost their jobs based on their pitch calling inaccuracy.\textsuperscript{43}

To be sure, human umpires are fallible. Some analyses suggest that, in aggregate, umpires make “bad calls” (defined as being incorrect by PITCHf/x standards) about 15\% of the time.\textsuperscript{44} Moreover, umpires show bias in their ball/strike calls based on the present count. Umpires are less likely to call a fourth ball on a three-ball count or a third strike on a two-strike count—in other words, when the stakes are high, umps change the size of the strike zone to minimize pivotal calls.\textsuperscript{45} By comparison, PITCHf/x exhibits no such bias, and has an accuracy rate of 99.87\%; those errors that exist seem to be primarily due to hardware faults or glare.\textsuperscript{46} However, when PITCHf/x fails, the reasons can be less clear than when an umpire misses a call: in the words of Dan Brooks (founder of BrooksBaseball.net), reliance on PITCHf/x instead of human umps would mean that baseball fans are “willing to accept a much smaller amount of inexplicable error in exchange for a larger amount of explicable error.”\textsuperscript{47}

Analyses demonstrate that the rollout of QuesTec corresponded to a larger enforced strike zone starting in 2001, resulting in less offensive productivity and fewer bases on balls (walks) per game, as compared to the “hitting barrage” of the 1990s.\textsuperscript{48} This suggests that the QuesTec-enforced strike zone was, in fact, in closer compliance with the rulebook definition than the effective strike zone that had preceded it. In addition, the spread between specific umpires’ strike zones decreased by about 25\% in the QuesTec era.\textsuperscript{49}

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\includegraphics[width=\textwidth]{figure.png}
\caption{Base on Balls per Game, 1960-2007 Seasons}
\end{figure}

\begin{itemize}
\item \textsuperscript{44} http://www.beyondtheboxscore.com/2014/1/27/5341676/how-well-do-umpires-call-balls-and-strikes; see also https://fivethirtyeight.com/datalab/playoff-umps-are-screwing-up-a-tenth-of-balls-and-strikes/
\item \textsuperscript{45} http://www.sloansportsconference.com/wp-content/uploads/2014/02/2014_SSAC_What-Does-it-Take-to-Call-a-Strike.pdf
\item \textsuperscript{46} http://grantland.com/features/ben-lindbergh-possibility-machines-replacing-umpires/
\item \textsuperscript{47} http://grantland.com/features/ben-lindbergh-possibility-machines-replacing-umpires/
\item \textsuperscript{49} http://www.hardballtimes.com/the-outside-corner/
\item \textsuperscript{50} Figure reproduced from Rader, Benjamin G., and Kenneth J. Winkle. "Baseball's great hitting barrage of the 1990s (and beyond) reexamined." \textit{NINE: A Journal of Baseball History and Culture} 17.1 (2008): 70-96.
\end{itemize}
Automated ball/strike systems have changed the way the game is played. Since the advent of camera technology, umpires are more likely to call strikes near the bottom of the zone (around the batter’s knees)—swinging strikeouts increased 11% between 2008 and 2013, and called strikeouts increased 66% over the same period, entirely due to changes in pitches at the bottom of the strike zone. Pitchers are more likely to throw low pitches now, leading to fewer (and worse) hits, and contributing to what many see as baseball’s current offensive drought; the change has also impacted the work of outfielders, who see much less defensive action than they did before the cameras.

This result, as Derek Thompson writes, can be read as the MLB getting what it wanted—more by-the-book strike-zone enforcement—but losing the excitement of the game: “[b]aseball has done all the right little things while perhaps ignoring the big thing: It needs hitters. It needs home runs. … Umpires, empowered and/or cowered by technology, are better than ever. As a direct result, baseball has become a grind for fans who prefer sports with scoring.”

In the major leagues, PITCHf/x has not (yet) been used to officiate a game on its own—but a 2015 independent league game, between the San Rafael Pacifics and the Vallejo Admirals, was called with the system calling balls and strikes on its own (in fact, a human voiced the machine’s “balls” and “STRIIKEs”, but only for effect). The event was seen as something of a

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51 For detailed year-by-year analysis: http://www.hardballtimes.com/the-strike-zone-during-the-pitchfx-era/
novelty, promoted on Twitter as #RoboUmp—but gave a glimpse of a possible future of baseball officiating.56

III. The Gentleman’s Sport: Golf

The culture of golf is quite different than that of football and baseball. Golf is old; modern golf goes back nearly six centuries, and the first official rules of golf predate the United States by three decades. There were thirteen rules originally established by the The Honourable Company of Edinburgh Golfers, which read like this one (Rule #10): “If a Ball be stopp'd by any Person, Horse, Dog or anything else, The Ball so stop'd must be play'd where it lyes.” Today there are 34 Rules (spanning just under 100 pages), in addition to the Decisions of the Rules of Golf (which serve as a kind of common law and span 457 pages), both the product of a collaborative effort between the United States Golf Association (“USGA”) and the Royal and Ancient Golf Club (“R&A”). Every four years the Rules of Golf are reviewed to “ensure they are relevant to the modern game while maintaining golf’s best traditions.” The rules of golf are notoriously difficult to understand and comply with.57 In 1919 a popular “Illustrated Golf Rules and Etiquette of the Game” was published to both make light of the complicated rules and help players maneuver through their complexities.

Fig. Caption of image reads, “Young America calls to the Ancient Golf Layer to get out of the way with his obsolete laws.”

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This tradition continues. Today, the USGA has its own video series called The Rules of Golf explained.

Rule enforcement has been and continues to be left to the players; golf is a gentlemen’s sport. Today, players are still supposed to call their own penalties, but there are “referees” roaming the course. The referees, sometimes referred to as officials, are most often seen when players have a question about a rule in their particular (never good) situation, and carry the air of an adviser as opposed to enforcer. A referee is defined as “one who is appointed by the Committee to decide questions of fact and apply the Rules. He must act on any breach of a Rule that he observes or is reported to him.” Even without a reputation for corruption or dishonesty, golf is also regulated by fans, who can and do inform referees of rules infractions. This is done to adhere to golf’s rule-fanaticism rather than impugn the integrity of players.

Television changed golf play and rules in a unique way: because stroke penalties or disqualification can occur after play has concluded, evidence of a rule infraction can be considered long after it has occurred, and irregularities are sometimes reported by home viewers. In 2014, a rule violation committed by Tiger Woods was called in by a viewer, which is not discouraged. David Eger was casually watching the first round of the Masters when he noticed Woods’s current score and rewound to see Woods hit into the water on the hole prior. Woods “took his drop,” meaning he held the ball in his hand at shoulder height and let it fall to the ground, and Eger watched his first shot and the second dropped shot—seeing that he took a divot (a large and noticeable chunk of grass) on the first that could not be seen on the second. Eger determined that Woods must have violated Rule 26-1-a, which requires a player to drop “as near
as possible” to the original location of the water-bound shot. Eger, who was a well-established golfer and official, called some former colleagues he knew were working the Masters and eventually told them of the violation. There had been no officials around and Woods had not asked for help so Eger’s analysis of the incident, relying on a divot, was not conclusive enough for the committee chair to act on, but when he explained in a post-round interview with ESPN that he had dropped his ball two yards back from his original position to get a better angle and spurring Twitter scrutiny of its legality, the officials had to dock his score.58

An extraordinary rule, Decision 18/4, was passed by the R&A and USGA in 2013, after a number of penalties had been assessed using high definition video to review play. The Decision addressed Rule 18: Ball at Rest Moved, which explains that if a player causes his or her ball to move, the player incurs a penalty of one stroke and must move the ball back to its original location. In a joint statement the rules committees explained, “New Decision 18/4 provides that, where enhanced technological evidence (e.g. HDTV, digital recording or online visual media, etc.) shows that a ball has left its position and come to rest in another location, the ball will not be deemed to have moved if that movement was not reasonably discernible to the naked eye at the time.” Padraig Harrington suffered at the hands of viewers when the “couch potato police”59 called in claiming to have seen his ball move a fraction after he returned it to the green when done marking its location and cleaning it up. Harrington had not noticed it move at the time but once reviewed in slow-motion HD, he admitted it move a few dimples and was disqualified because he signed an inaccurate scorecard having not included the penalty stroke.

Decision 18/4 supplemented the 2011 change to Rule 33-7, which waived disqualification for a player who signed a scorecard following a round in which that player committed a rules infraction discovered later through video evidence, a response to numerous incidents that had occurred in prior years. The rules committees chose to go a step further in Decision 18/4 allowing only human perception, or “reasonably discernible to the naked eye at the time,” to establish infractions. Thus, at least for determining whether a ball at rest has moved, it is not accuracy of the call but the autonomy of the players to be honest that retains the essence of the sport. Michael Fitzgerald explains the potential problem with this rule on the Bleacher Report, “There are bound to be numerous instances of a player not accepting a penalty on the basis of having not seen their ball move with their naked eye, while the general public, media and even their peers may disagree, thus increasing the likelihood of the dreaded ‘cheater’ term being tossed around the game a bit more often.”60

Decision 18/4 was invoked in May 2014; Justin Rose incurred a two-stroke penalty after he addressed a chip shot and then suddenly backed away. Rose did not think his ball had moved from its original position and consulted his playing partner, who agreed. It took a third television angle, zoomed in very tightly to see that the ball had in fact moved, but after the Rules

Committee of the Players Championship reviewed the determination, it declared that “the only way to confirm whether and how much the ball in fact changed position was to utilize sophisticated technology.” To be clear, the Rules Committee had to use video evidence to determine that the penalty could have only been perceived through video evidence and not by the naked eye.

The Professional Golfers Association Tour began to use instant replay in March of 1990 after a television viewer in Colorado reported a player who had set a towel under his knee to avoid getting mud on his pants during an awkward shot. The player was in violation of Rule 13 because he had “improved his stance” and ultimately disqualified. After the incident, the tour placed an official in a TV trailer to monitor for rules infractions at the following several tournaments. This was a wildly unpopular decision, and in 1991, the PGA Tour discontinued the use of instant replay to enforce rules during tournament play. In a unanimous vote, the Tour’s policy board elected to stop their practice of having a player monitor all play that was televised and go back to a self-monitoring enforcement system. This would not diminish accountability, as Commissioner Deane Beman explained, “The players are going to be fully responsible for their own actions, but they understand that they are still going to be monitored by millions of golf fans.”

Dustin Johnson’s putt on the 5th hole at the 2016 U.S. Open reignited the issue. Although video enhancement cannot be used to determine that a ball has moved, it can be used to determine whether a ball that had clearly moved did so because of the actions of a player. Johnson was taking a practice stroke when his ball moved and he called over a referee. He explained to the referee that he had not caused the ball to move and his partner confirmed, so the referee told him no violation occurred, but the incident was referred to a higher up by an official assigned to video review. Johnson played for two hours, not knowing whether he was still at the top of the leaderboard, while officials reviewed footage to determine if he had touched his ball or not. Video evidence is not always conclusive and the Rule 18-2/0.5 states, “If the weight of the evidence indicates that it is more likely than not that the player caused the ball to move, even though that conclusion is not free from doubt, the player incurs a one-stroke penalty under Rule 18-2 and the ball must be replaced.” (While the video was looked at numerous times, the delay was actually due to the officials waiting for Johnson himself to review the footage. When he did, as the winner of the Open either way, Johnson simply said, “OK, whatever. Let's just get on with the prize presentation.”)

Many technologies could be used to provide real-time feedback to players and officials to enforce rules. For instance, the incident that pushed the 1991 PGA policy change involved the TV official contesting the judgment of Tom Kite, who had determined that his ball had gone out

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62 This is exactly how the Decision is intended to be applied and described specifically in the Q&A following Decision 18/4.
of bounds on a trajectory that allowed him to play off a portion of grass. The TV official thought that the trajectory required him to re-hit from the tee box, meaning it had not flown over any portion of the hole that Kite could have dropped his ball. Plenty of smartphone apps, clubs, and balls today could be used in such a situation to make the correct call, but these technologies are of no interest to the sport. Certainly, Johnson could have used a ball that could detect whether his putter had made contact or not.

The USGA has a rules hotline to call for help. When we inquired about the current status of instant replay for identifying violations, we were informed that, for now, use is at the discretion of each committee (those in charge of a specific tournament, like the PGA Tour board in 1991) and that instant replay is the subject of an ongoing, deeper study.\(^{65}\) We were also informed that tracking technologies are covered (and probably not allowed) by Rule 14-3: Artificial Devices and Unusual Equipment; Abnormal Use of Equipment and Appendix IV.5: Distance-Measuring Devices, which are only allowed when stipulated.

Golf is not immune from the challenges other sports like baseball and football encounter in relation to rule changes and commercial interests. Golf has been in decline since the economic downturn of 2008, with more than 800 courses closing over the last decade and manufacturers and retailers struggling,\(^{66}\) but professional golf remains strong, supported by sponsors and advertisers trying to reach wealthy, older, male fans, even as that number is decreasing and ratings falling.\(^{67}\) It is in this unpopular state that the Rules Modernization Project has been initiated. The RMP is intended to make golf’s rules easier to understand and “fairer,” but will not give up playing the ball where it lies and play the course as you find it—considered vital to the “protection of the core principles behind the rules.” The rule changes include a six month period for feedback and evaluation, ending August 31, 2017, and will take effect January 1, 2019. Though there is no requirement that the committee consider the feedback from fans and golfers, but the attempt to engage the public in rule formation is in stark contrast to other sports.

IV. Order on the Court: Tennis

Up until the mid-1990s, an umpire sat at the end of the tennis net and placed a finger delicately on the cord before each and every serve in an attempt to feel the vibration of a ball making contact. In 1996, the four Grand Slam tournaments all began using a piezoelectrical device generically referred to as a net-cord sensor. Jay Snyder, U.S. Open Tournament director at the time, explained, “Typically, I think you have more arguments over let calls than line calls these days. But I think the most important issue here is that net umpire is probably the least safe position for an official.”\(^{68}\)

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\(^{65}\) Phone call Mar 6, 2016.
\(^{66}\) http://www.golf.com/equipment/nike-will-stop-making-golf-clubs-golf-balls-golf-bags
Tennis had already automated some line calls when the net-cord judge lost his job. Since the 1980s, tennis relied on Cyclops, an “electronic line judge” that used a series of infrared laser light beam projections to determine if a serve was long. One beam ran across the “in” portion of the box and four ran across the “out” portion of the box (extending 18 inches back from the service line); the “control box,” operated by the service line umpire, gives a green light if the first beam is broken and a beep when any of the red beams were broken.

Cyclops had some pretty severe limitations. It could only be used on the service line because rackets and feet set it off. Bugs also set off the system. Cyclops was supplemental to human umpires. “The line umpire has the final call and can shut down the system there are questions about its accuracy.”

Today, tennis relies on Hawk-Eye, a system that takes thousands of measurements of each court to create a 3D rendering of the court (done repeatedly on grass courts with changing contours throughout a match). Using ten high-speed video cameras placed at various locations and at various angles around the court, Hawk-Eye calculates a 3D position of the ball using frames sent from each camera. It produces a digital trajectory of the ball and displays a simple and definitive “replay” of the shot.

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69 This claim has not been verified by analysis of the official rules and is only based on anecdotal accounts from officials and players.
Hawk-Eye was not the first to try to supplant Cyclops and Cyclops was not the first of its kind. For example in 1970s, the Grant-Hicks apparatus used pressure sensors under the court’s surface to detect the impact of the ball, but like a few other related inventions, was not commercialized or widely implemented. In the late 1980s Accu-Call, which involved a fine mesh electrical grid being laid across the court and balls laced with metal strands, was used to train officials, but never fully incorporated into the sport. And in the early 1990s, TEL, described as “part Star Wars, part metal detector,” involved magnetized balls and a court buried with wires on each line, and was installed at the Australian Open—but never supplanted Cyclops. After a multistakeholder panel (governing bodies, players, equipment manufacturers, and television commentators) in 2003, a group of governing bodies produced a protocol for the evaluation of automated line-calling systems that included three phases (laboratory conditions, test tournament conditions, and live test). It tested Auto-Ref under these conditions, but Hawk-Eye met the standards in 2005 and was used at the Hopman Cup in 2006. With a 3.6 millimeter average margin of error, Hawk-Eye is not perfect, especially with pesky shadows on the court. Nonetheless, it is displayed on the Jumbotron and televisions world-wide, capturing rapt attention of players, fans, and even the umpires as all wait to see where the ball “truly” hit the court.

Three out of ten challenged calls are overturned by Hawk-Eye. Introduced in 2002, the system gained widespread recognition in 2004 at the U.S. Open and was incorporated into the player-challenge rules of 2006. Though most players and fans were enthusiastic, Roger Federer

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75 http://www.itftennis.com/technical/technical-centre/line-calling.aspx 
said, “I am against the whole idea of replays.” As of March, 2008, a player can make up to three unsuccessful challenges per set and a fourth during a tie-break—a rule the four governing bodies of tennis (the International Tennis Federation, the Women’s Tennis Association, the Grand Slam Committee, and the Association of Tennis Professionals) all agreed on.

Unlike the rules of golf, those of tennis are not well-documented or archived—nor is there a hotline, video series, or throwback Thursday. In the 2017 ITF Rules of Tennis, “Electronic Review Procedures” state that the chair umpire “should decide to use the Electronic Review when there is doubt about the accuracy of the line call or overrule,” but can also refuse to use the ER if the umpire believes the player is making an unreasonable request. If the ER is unable to make a decision, the umpire’s call stands, but if the ER system can make the call, “the chair umpire’s final decision will be the outcome of the Electronic Review and is not appealable.” The Hawk-Eye system has the final word in tennis. Electronic review is included in documentation going back to 2007, but no discussion of the rule’s introduction or implementation by any governing body could be located.

The ITA has chosen to present Hawk-Eye graphics as precise, but cricket is more transparent, revealing when Hawk-Eye is uncertain and when umpires should use their own judgement. Referred to as DRS (decision review system) in cricket, ball tracking technology, along with sensitive audio and infra-red imaging, is used to show the likely path of the ball to determine if it the pitch bounced in the proper area and would have hit the wicket in analyzing leg before wicket decisions (a batsman is dismissed if an umpire rules that the ball would have struck the wicket but for hitting the batman’s body). Close calls are referred, by Hawk-Eye using a color coding scheme presented to the viewer, to the third umpire who assesses the call using traditional slow motion video playback.

Fig. Verifies original LBW decision (meets all criteria to dismiss batsman)

77 ITF has histories on rule changes to balls, rackets, courts, and technology used by athletes.
78 The hunt continues!
The complex leg before wicket rule has been controversial, confusing, and error-prone since its inception in the early 1900s. David Fraser explains, “Technology is thus introduced into the adjudicative process in this part of cricket and the law as a result of the incompetence critique. In other words, umpires are not capable of meeting minimum standards for deciding LBW cases.”

Similar complaints are made in tennis about line calls (not considered a complex rule); in 2006, a USTA executive stated simply, “With the speed and power of today’s game, and with 150 mile per hour serves and 100 mile per hour backhands, we need an officiating aid.”

Perhaps this added level of technological truth (displaying Hawk-Eye’s level of certainty and referring to an umpire when it drops below a certain level) would be unpleasant for fans and umpires, especially since, other than Federer, the only criticism of Hawk-Eye is that it is not on every court. The way tennis uses Hawk-Eye is exciting, consistent, fast, authoritative, and seemingly precise. In explaining Hawk-Eye’s acceptance in tennis, chief umpire for the US Open said, “We didn’t want long delays like in American football, where you have to go through three

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80 David Fraser, Cricket and the Law: The Man in White is Always Right (2003), 132.
81 http://www.washingtonpost.com/wp-dyn/content/article/2006/03/05/AR2006030500974.html
ads before you get a decision. The good think about Hawk-Eye is the results are immediate.\textsuperscript{82} The drama of calls in tennis comes in short, shared bursts. It is not the extended, complex melodrama of golf.

“In a post-Hawk-Eye world, elite-level tennis is injected with the purest form of justice: the kind that’s unblemished by human error... Machinery baldly exposes the unintentional unfairness of tennis’ long-standing tradition of human umpiring.”\textsuperscript{83} Except on clay. The French Open, the Grand Slam tournament famously played on clay, has never considered using Hawk-Eye or any other technical support for line calls. On clay courts, human umpires make calls by assessing where the ball has made an imprint in the surface, and players see the same imprint and make challenges based on analysis of the mark. There is no perceived need to computationally reconstruct what can be seen by the human eye, and the lack of technological support remains a point of pride and distinction for the French Open. Using clay markers is not perfect either; wind, dryness, and inconsistent clay accumulation can alter the size of the mark relative to its actual impact.\textsuperscript{84} The French Open is equipped with Hawk-Eye on two of the main courts, but is used for television broadcasts and not seen in the stadium. Comfort with clay court line calls seems to be part of the foundation for the sport’s acceptance of Hawk-Eye. Rich Kaufman, USTA director of officials, said, “The players understand clay-court procedures. The umpires understand clay-court procedures, and because of that, I think there has been a very easy adjustment for everyone.”\textsuperscript{85} The circle in relation to the line, whether generated by the physical ball dispersing clay dust or digitally using sophisticated mathematics, is accepted as a simple and easy way to accurately make line calls.

Tennis is even older than golf with roots in the 12th century, and modern tennis being played in the 16th. It is also considers itself a gentleman’s sport, originally marked by its deference to authority and altruism. If an umpire made a bad call, the beneficiary of the botched decision would throw the next point and be greeted with appreciative applause.\textsuperscript{87} Traditionally and more importantly, tennis is an art; though it may seem like a duel, it is more like a dance.\textsuperscript{88} Pushed to fit into the traditional sports model since World War II, tennis athletes are considered extraordinarily athletic, strong, and agile, but retain an artist’s volatility or remoteness.

\textsuperscript{82} http://www.nytimes.com/2008/09/08/sports/tennis/08hawkeye.html
\textsuperscript{84} This is not true for the governing bodies themselves, who thoroughly explain the shortcomings of relying on such marks. “Humans may use ‘clues’ to the impact location... [S]uch information is not available to automated line-calling systems, which (in theory) should produce a more objective decision.” ITF, “Automated Line-Calling Systems: ITF Evaluation,” 2 (December 2016).
\textsuperscript{85} https://www.nytimes.com/2016/05/24/sports/tennis/french-open-clay-hawk-eye-review-line-judging.html?_r=0
\textsuperscript{86} http://www.nytimes.com/2008/09/08/sports/tennis/08hawkeye.html
\textsuperscript{88} Elizabeth Wilson, Love Game: A History of Tennis From Victorian Pastime to Global Phenomenon, 3-5 (2016).
Today, the player-umpire relationship is described as abusive, and intimidating umpires considered a tactic for getting favorable calls. In the 1980s players like Jimmy Connors (who called an umpire an “abortion” and told him to “Get out of the chair, you bum.”) and John McEnroe (who told one umpire, “You are an incompetent fool, an offense against the world,” while slamming his racket against the chair) were legendary for their belligerent tempers. In 2011, Serena Williams lost a point for yelling “Come on!” during a point, and responded by berating the umpire, saying “You’re nobody. You’re ugly on the inside. We were in America last time I checked... What a loser.”

Although players are fined for such behavior (rules prohibit “ball abuse”), the heated interactions create an entertaining spectacle for fans who will share the videos of these outbursts online. One avid tennis fan explained, “Connors and John McEnroe were very entertaining. Automatons hitting tennis balls with no emotion is not much fun. You like to see some interaction with the crowd, opponent, even the umpire. So while these incidents should be condemned by the authorities and fines imposed where necessary, they’re also good for the sport as they certainly get people interested.” Commentators on Hawk-Eye frequently mention calming effect the system has to the emotional and mental state of players. “Even when players are incorrect, and the original call stands, it means the player relaxes more. They’re contented; they’re not gonna get agitated, and hopefully raise the bar on the level of tennis that everyone’s gonna see.” Hawk-Eye essentially eliminated umpire abuse for challenged line calls, but humans still call make all the initial line calls and enforce other rules like no in-match coaching (cannot consult coaching staff during match) and no deliberate hindrance (cannot shout things while ball is in play).

Although tennis is, in theory, about the simplicity of two players facing off head to head, there are still up to ten officials ringing the court, even with all that technology on hand. McEnroe has advocated, with some support, for getting rid of the umpires entirely, and having players call their own lines with Hawk-Eye there to make all final judgements. His motivation? “I guarantee you that tennis would be like 30 percent more interesting.” At least for some, the drama is not about challenging the authority of the human referee that creates the drama but tension between players, accuracy of calls, and big money prizes. Though technologically

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92 http://www.theguardian.com/sport/blog/2011/sep/12/serena-williams-abuse-open
possible, only a few have advocated for Hawk-Eye simply make every single line call on the court, reducing the number of umpires to one.\textsuperscript{96} For those that want the full human drama, there is always France.

V. When Rules are Made to be Broken: Sociocultural Rhetorics and Structural Considerations

This survey reveals a number of competing interests and sociocultural dynamics that impact the adoption of automated enforcement systems in sports. At a minimum, the survey reveals that culture matters significantly to the introduction of automated enforcement. Each governing body confronts technologies of enforcement by assessing its impact on the numerous facets of game, both structural and cultural. Sociocultural rationales and structural considerations are at work in non-sports contexts as well, but tend to be undertheorized; sports might help us recognize where these factors emerge more generally in debates about automation.

A. Theaters of unpredictability

Technology can both create and mitigate drama in an activity. Body cams have created policing theater with dramatic visuals, but also mitigated some of the drama stemming from the unknown in certain interactions. The drama of killer robots has supplanted some of the drama of the heroic fighter pilot. The dramatic aspects of life, like those of sports, cannot be snuffed out by technology; rather, they may be reordered when technology is introduced.

In sports, enforcement technologies can both augment and suppress drama. The technologically augmented re-viewing of a contentious play—the slow motion, multiple camera angles, voiceovers by commentators while officials render a judgment—can create a moment of genuinely enjoyable tension that is an integral part of the spectacle of sports viewership, and which extends into next-day adjudications among fans. Dramatic tension begets viewership and engagement, which is, by most accounts, good for sports (not least because it increases prospects for revenue generation). After Joe Torre admonished MLB managers to stop throwing tantrums about ump’s ball/strike calls—a practice facilitated by the presence of replay technology—sportswriter Claire McNear made the case that these performances are themselves part of what spectators are there for: “Look at this spittle-spattering! This halitosis-harkening! ... Goddamnit, baseball, this shit is great, OK? Leave it alone. Manager tantrums are not only an old tradition—they’re a great one. If the end result of pace-of-play guidelines is to make baseball more exciting—well, hell, this sure seems exciting to me. … We don’t need to hand the whole game over to rule-minding cameras and robots to acknowledge that this is clearly a specificity that fans enjoy.”\textsuperscript{97}

\textsuperscript{96} http://www.sportsbusinessdaily.com/Journal/Issues/2015/08/31/In-Depth/Tennis-lines.aspx
\textsuperscript{97} https://theringer.com/the-case-for-more-challenges-in-baseball-3029d3ab288d#.uij6yv1ldj . As Brian Lam, an attorney for the umpires union, put it: “One of the biggest complaints of instant replay is that managers and players can’t yell at umpires anymore. We don’t miss (the arguing) but we acknowledge that’s part of the game.” And the Orioles’ Buck Showalter: “Arguing is something you used to work on. It’s a skill-set that slowly being phased out.”
But too much predictability, too much automation in judgment, might subdue this theatrical tension. If a light blinks red or green to indicate whether a plane has been crossed, without a need or role for human interpretation, fans are excluded from a facet of the game to which they had previously been privy, even if they lacked actual adjudicative power.

At the same time, as mentioned, some concern about limiting the role of technology in officiating (particularly, mandated replay of plays) relates to the pace of games, a key concern for fan engagement and broadcast. Interestingly, some who oppose extensive replay review see more fully automated enforcement (like goal-line technology) as preferable alternatives, precisely because they render judgments instantaneously, thus keeping the action moving; in the words of commentator Joe Sheehan, “if you’re going to make baseball more watchable, you’re going to have to generate more contact, and that eventually means automating the strike zone.”

This all suggests, more broadly, that the process of administering determinations—and the burdens it imposes—is a consideration to be weighed in the evaluation of an automated rule enforcement system. As sportswriter Colin McGowan put it:

American sports leagues' dogged commitment to fairness is admirable, in a doofily dutiful sort of way, but we do not watch sports to observe justice being meted out in real time. We want to see the players run and jump and dive. We want as much of that as possible, with minimal intervening administrative bullshit.

After all, in addition to everything else that sports are, they are entertainment—that can be its most dramatic and engaging when the rules are broken. As a Vice Sports writer described an officiating snafu in a Bills/Seahawks matchup—a confusing series of events precipitated by the refs’ failure to call an unnecessary roughness penalty on Seahawks cornerback Richard Sherman against the Bills’ kicker, ending eventually in a missed Bills field goal—“[t]he machinations of rules, when and how they are enforced by the human beings responsible for enforcing them, created a bizarre sequence that essentially robbed the Bills of three points. ... [T]his is what makes the NFL great. This is what has been missing all year; that one inexplicable moment that ripples through the game and has everyone talking the next day.”

100 https://sports.vice.com/en_us/article/death-to-replay-review-forever
101 https://sports.vice.com/en_us/highlight/bills-seahawks-proves-the-nfl-is-at-its-best-when-it-screws-up/ (emphasis added; see also National Basketball Referees’ Association Position on the Current L2M Reporting Policy (“Focusing on officiating statistics encourages stat-oriented, versus game-oriented, officiating. It is in the best interest of the NBA and its fans to encourage and develop
B. **Bad calls as adversity**

The narrative arc of sports success requires that adversity be overcome, in life and on the field. The sports heroes who most readily capture the popular imagination have faced down unfairness, from health setbacks to difficult childhoods to the obstacles of racism and classism. Watching athletes rise above such challenges to meet success on the basketball court or the football field makes their victories that much more dramatic, satisfying, and cathartic to the sports fan.

The uncertainty and risk of the action on the field can serve the same purpose. Teams make mistakes, claw back from deficits, face down injuries—each of which raises the emotional stakes of an eventual victory. Bad calls by officials can be understood as fitting into this category of hardships to be overcome. Heroes require injustice to be heroes.

C. **Sentiment, custom, and tradition**

Custom and tradition play a sizeable role, as well. The *soul* of the sports endeavor, some believe, is sullied by overreliance on data; as one commentary on ESPN’s televised strike zone observed critically, “[t]he calculus at the root of this experiment seems to be that we prefer perfect information to beauty, precision to custom.”¹⁰² Some sports fans are notoriously resistant to the use of data and analytics of any sort (for instance, see Arizona Diamondbacks’ GM Dave Stewart’s recent comment that the Diamondbacks were “a true baseball team, versus some of the other teams out here that are geared more toward analytics and those types of things.”¹⁰³).

In any event, sports derive some of their cultural and social significance due to the fact that *things are generally done the way they always have been done*. To alter the structure of the sport too much would be to separate it from its longevity, from the idea that generations of fans have experienced the sport in, more or less, the same way we do today. For instance, the longstanding and anachronistic tradition of hand-scoring baseball games persists today for many diehard fans, despite the fact that such manual recordkeeping is made wholly unnecessary by modern technology.¹⁰⁴ Resistance to change is quite commonly a feature of discourse around technology adoption, but may have extra salience in the sports context, where the intergenerationality of sports spectatorship gives custom a personal dimension for many.

D. **Ontological reasoning and the “integrity of the game”**

An additional objection commonly raised is that somehow the sport *just wouldn’t be what it is* were it officiated by robots rather than humans. Though this objection relates to the custom

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¹⁰² [https://sports.vice.com/en_us/article/against-espns-k-zone-which-is-the-worst](https://sports.vice.com/en_us/article/against-espns-k-zone-which-is-the-worst)
¹⁰⁴ Dickson, The Art of Keeping Score
and tradition arguments raised above, it has a distinct quality: that, somehow, the *integrity* of
the sport is threatened by automated officiating. Golf with smart ball technology isn’t merely a
different version of golf from that played 50 years ago; rather, it isn’t golf *at all*.

Though this objection may seem inchoate or exaggerated, it is voiced with regularity. For
instance, on a recent episode of HBO’s *Real Sports*, commentator Bryant Gumbel criticized
automated ball/strike calling as “tantamount to a crime against humanity.” When Bernie
Goldberg pressed him as to why (“What if it’s the seventh game of the World Series? A bad call
decides for the wrong team? You think that’s better?”), Gumbel stated: “the important thing to
me is *not* getting it right. The important thing to me is preserving the integrity of sports. That it is
*sports*. … What’s next? Do we put a chip in everybody’s cleat so we can tell if they reached
the bag before a tag? … It’s *sports*. It’s supposed to be a game. That’s what it *is*. It’s not a
technological experiment.”

E. **Embodiment, beauty, and humanity**

Some pushback against “over-technologizing” in sports seems to be related to the
*fundamental humanity* of the sports endeavor. Perhaps no other activity is so clearly designed to
represent the apex of human physical capability. Relying too much on technology seems to be an
affront to the embodiment of the sport.

This tension emerges most strongly in debates about the use of technology to augment
human performance (e.g., doping, certain types of attire and equipment) but also is felt in the
officiating context. When QuesTec started to be used in MLB ballparks, it was criticizes as
“robbing the game of poetry.” And some of the embodiment of sports includes the ability to
tailor one’s actions to the other humans involved in the exchange: as Ben Lindberg put it,
“standardizing the zone would remove a level of interplay between batter, pitcher, catcher, and
umpire that many fans find compelling. No longer could a savvy pitcher with pinpoint command
annex extra territory off the corners … or learn how to tailor his approach to each umpire’s
personalized zone. … While these changes might make the batter-pitcher confrontation fairer,
they would also sap it of some of its nuance[.]”

The chain gangs in football, no matter how flawed, appear to be in no danger of losing their jobs to robots.

A similar hesitation underlies some concerns about automation in non-sports contexts—
notably, in debates about the automation of labor. Critics of labor automation express concern
about the demise of the physicality of work, the embodiment of craft in the hands that stands to
be lost (or undervalued) with the advent of automation.

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105  https://www.youtube.com/watch?time_continue=1&v=_OrmfHbl8o
107  http://grantland.com/features/ben-lindbergh-possibility-machines-replacing-umpires/
108  Sennett, The Craftsman
F. **Honor, dignity, and etiquette**

Reliance on technology for rule determination seems, in some contexts, to be an affront to the *dignity* of a sport. Perhaps reliance on technology suggests that players and officials cannot be trusted, in the absence of technology, to behave ethically, which can be viewed as an insult to the honor of the sport and those who engage in it. Nowhere is this clearer than in golf, in which the “gentlemanliness” of the sport requires that players self-acknowledge their own penalties.

A similar rhetoric arises in professional bridge. In tournaments, players are not permitted to exploit all “tells” from their partner across the table (e.g., signals, such as delay in bidding, intended to convey information about the content of their hand). The notion of personal propriety operates strongly here: “[p]rincipled players do their best to ignore their partner and play at a consistent tempo, in order to avoid exchanging unauthorized information—and, if they do end up noticing something they shouldn’t have noticed, they go out of their way not to exploit it. Unprincipled players consciously take advantage of such information,” including, occasionally, through overt cheating (like establishing *ex ante* a code of signals, like positioning of feet, hands, cards, cigarettes, or well-timed coughs).\(^ {109}\) In order to limit possibilities for cheating, some architectural changes have been made in tournament play—including fitting tables with screens to limit partner visibility, and dividers under the table—and are commonly videotaped, allowing for after-the-fact review of egregious cheating. But when presented with the possibility of addressing the problem through digital means—for instance, using a computerized tournament table in which there are no physical cards—players have expressed that they would prefer to instill “a firmer cultural commitment to ethical play” rather than trying to make malfeasance impossible.\(^ {110}\)

In non-sports contexts, related issues arise in the context of surveillance. In research about electronic monitoring in labor contexts, surveilled workers express frustration about the adoption of monitoring technologies indicating that they were not to be trusted to follow rules themselves.\(^ {111}\)

G. **Competing Interests and Structural Considerations**

*The players.* What is the role of the player in relation to rule enforcement? Are they rewarded or shunned for rule-breaking in the sport? What is the role of honor and sportsmanship in relation to rules? In golf, players are the keepers of the integrity of the sport, securing their position in the sport by adhering strictly to the rules; in football, on the other hand, players are rewarded for cleverly circumventing the rules, part of the strategy and show of the game.

Looking beyond sports, we can ask: what actors are considered “players”? With whom do they compete? For instance, law enforcement agents may be seen as players in competition with criminals; employers are considered players in relation to employees, hunting the bottomline.

\(^{109}\) [http://www.newyorker.com/magazine/2016/03/07/the-cheating-problem-in-professional-bridge](http://www.newyorker.com/magazine/2016/03/07/the-cheating-problem-in-professional-bridge)

\(^{110}\) [http://www.newyorker.com/magazine/2016/03/07/the-cheating-problem-in-professional-bridge](http://www.newyorker.com/magazine/2016/03/07/the-cheating-problem-in-professional-bridge)

\(^{111}\) e.g., Levy 2014, in which monitored truck drivers stated that they felt they were being treated as children or as criminals
Because of the competitive positioning of some groups relative to others, our expectations about the strategies those groups are likely to espouse in relation to rule enforcement are likely to vary, and may not encompass a holistic assessment of what is fairest for all.

**The officials.** What is the role of the official in relation to the culture of the sport? Are they managers of order and decorum - babysitting fitful tennis players, for example? Or are they tacticians of accuracy, as in football? What does a bad human call mean for the essence of the sport? This question can be posed outside of sport. Whose job is it to maintain the essence of an aspect of society? We may have specially assigned keepers - like judges - or we may leave enforcement to norms - like parenting. If no assigned keepers exist, how is the integrity of an activity maintained?

**The rules.** Is the sport rule-heavy, or based on standards and guidelines? How much public scrutiny is the governing body given? How are rules changed? Why are they changed? The organization, exclusivity, and secrecy of the governing bodies matters greatly to rule changes and their introduction. Golf has made special efforts to make rules more accessible, whereas the hotly contested rule-changes in baseball and football are often criticized as being about television viewership and making money. Rules beyond sports have similar characteristics. Are rules considered simple or complex? Who makes the rules and how? What purposes or interests do rule changes serve?

**The fans.** How do the fans matter to rule enforcement? How are they a part of the sport? Do they participate—meaning, are the rules also for them? The degree to which fans themselves have access to (even unofficial) officiating data also impacts perspectives on adoption. The “home court advantage” relates not only to the support or degradation players feel from a wild crowd, but the way calls favor the home team due to crowd influence. Sports must take care of their fans, make sure they are invested in the sport, but the role of the fans can potentially be minimized (as in tennis) or maximized (as in golf) by the use of technology. For those not in a direct relationship with the automation of rules, how do they matter? How do consumers in trucking or non-drivers in cities that use automated traffic enforcement or Americans watching non-domestic military drones matter to debates about automating the activity? Should their input be considered directly, as in golf, or left to those that best understand the economics, history, and technological capabilities?

**The technology.** The specific technological infrastructures described in the case studies varies dramatically depending on the sport. This may be because play limits the utility of high-precision technology, as in football, or because it so dramatically impacts the essence of the game, as in baseball, or require tests and trial implementation, as in tennis. Each sport must ask

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112 https://theringer.com/nfl-mike-carey-rules-analyst-human-error-edd2226e9a29#.vcbhecexag -- “What is the role of a ref when we all have smartphones in our pockets? … By the time a challenge has been sent for instant replay, fans have watched the play repeatedly, from every angle imaginable. With the ability to see more has come ever shriller responses to blown calls, which fans are able to broadcast directly to teams, leagues, and networks via social media. Officiating errors—which are now known, with near immediacy and in excruciating detail—are not tolerated.”
itself how precise the technology needs to be for integration into the rules, and how it will be used in relation to the players and referees. Many use a challenge system, acknowledging that humans can easily make many calls but when it matters technology may be a useful supplement. How conclusive must the technology be to be relied upon—what is the applicable burden of proof? Technological integration outside of sports may be served well by similarly incorporating trial periods, transparency about uncertainty, and burdens of proof.

Conclusion

Sports offer us a focused reflection of social and political life: the issues of the day play out in the context of the football field, the tennis court, and the golf course. Though we often take note of how social issues—particularly political conflicts—influence play and affect players, we less commonly use sports as a lens through which to explore broader political debates. Technological officiating offers us the opportunity to do so: by examining contention around the use of robot refs, we may obtain greater purchase on the social and cultural issues impacting automation policy more broadly.

As we have described, a host of sociocultural factors help to explain some of the reticence around automated enforcement in sports, and may also be reflected in other contexts in which automation is at stake. Our analysis is intended to delineate and highlight the presence of these factors—and to demonstrate how they may lead to counterintuitive ends.

By closely interrogating how we enforce rules, we learn something about the rules themselves, and the purposes we want them to serve. In sports, the perceived infallibility of robotic referees, and the consistency of enforcement they could engender, can operate as justifications against their adoption, rather than (as we might expect) rationales in their favor. And, the justifications for utilizing their perceived infallibility serve some sports and aspects of a sport but not others. This shows us that we may want rules to be broken or able to be broken, for reasons ranging from custom and etiquette to drama and ontological integrity. The “sporting chance”—the possibility that enforcement be imperfectly applied, the play in the joints that makes rule violation desirable for a host of reasons—tells us something about the relation between humanity and automation. We ought to ask in what social contexts we might similarly want to leave room for such chance, and to interrogate when and how automation might impede this possibility.