Sports Innovation Journal, 2021, 2, 1–18
https://doi.org/10.18060/24247

X's and O's, Angles and Games: NFL Football Yardage Estimations Based on Camera Angle

Benjamin J. Lynn, Roxane Coche, and Ashleigh Messick

In 2017, NFL viewers complained when NBC Sports used the "Madden" camera for live play-by-play coverage of two Thursday Night Football games. Their comments indicated that they had a difficult time estimating yardage from the new perspective. Those games were just two recent examples of viewers complaining about changes in the visual presentation of live sports broadcasts—a phenomenon that has been happening with the Madden camera for more than a decade. The sports broadcasters' inability to adjust its production technique for live football coverage, despite repeated attempts, provides important insights about the nature of mass communication. As sports broadcasters continue to look for new production techniques in a constantly evolving media landscape, these findings could help guide their production practices. Using game footage from four NFL broadcasts, the present study tested for differences in yardage estimations made from the traditional game camera (i.e., a stationary camera perpendicular to the field) and the Madden camera (i.e., a moving camera on wires positioned over the field). Participants ($N = 473$) were randomly assigned to watch 11 plays from either the traditional game camera angle or the Madden camera angle. No significant differences were found in estimates of yardage gains based on camera angle. The high variance in the findings suggests that distance estimations are complex visual processes that may require specialized training to improve accuracy.

Keywords: broadcasting, football, NFL, Madden, sports, visual perception

---

Benjamin J. Lynn is a doctoral student in the Department of Telecommunication at the University of Florida. His research interests include live remote sports broadcasts, mediated visual communication, and esports. Email: b.lynn@ufl.edu

Roxane Coche, PhD, is an assistant professor in the Department of Telecommunication and associate director of Sports Journalism and Communication at the University of Florida. Her research interests focus on sports media practices and social issues in the sports media industry. Email: rcoche@ufl.edu

Ashleigh Messick is a graduate of the College of Journalism and Communications at the University of Florida. She currently attends Nova Southeastern University Shepard Broad College of Law as a Juris Doctor candidate. Her research interests include social media practices and trends, as well as intellectual property law. Email: ashmessick@yahoo.com

Introduction

In late 2017, NBC Sports produced two NFL Thursday Night Football (TNF) games using its four-point aerial camera system as the live play-by-play camera (Figure 1; Cooper, 2017), going against the tradition of using one of the three cameras positioned perpendicular to the field for that purpose. The initial feedback on social media and from sports journalists (Malyon, 2017; Ruiz, 2017) was positive, motivating the network to make a production change and use this camera—known as the “Madden” camera (Malyon, 2017) because the angle was first introduced in the Madden NFL video game (hereafter *Madden*)—for the entirety of two TNF games. Then, the positive feedback was replaced with mixed reviews (Adamski, 2017; Andrews, 2017; Gaines, 2017; Seifert, 2017) and social media users were

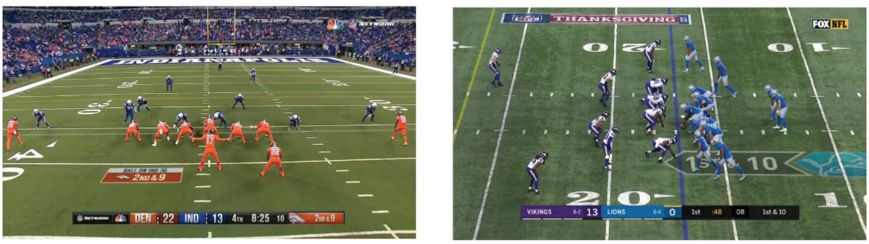

Figure 1. The Madden camera is positioned behind the offense and over the field while the traditional game camera is positioned perpendicular to the field of play and off the field.

deeply divided. Some loved the new look while others hated it (Andrews, 2017). From the feedback, some viewers had difficulty estimating yardage gains from the Madden camera, which could explain some viewers’ indignation.

NBC executive producer Fred Gaudelli, one of those behind the decision to use the Madden camera, acknowledged that estimating how far the ball went was difficult for viewers (Deitsch, 2018). Evidence indicates that sports broadcasters, like Fred Gaudelli, are not conducting empirical research to understand why their production changes create negative reactions in fans. For example, the NFL’s decision to use artificial crowd noise during its broadcasts was based on its own impressions of the content, not research (Bose, 2020). When asked how the network determines if new technologies are a meaningful part of its broadcast, longtime FOX Sports director Artie Kempner stated that they use a “how and wow” approach to evaluating technological changes. He admitted his network does not have a specific way of determining if changes have a positive impact on the production. However, “like pornography […] I know it when I see it,” he replied when asked how new technologies are evaluated for effectiveness

(Kempner, 2021). The broadcasters are clearly using what we might call a "common sense" approach to production practices: making production decisions based on their own feelings about the content—and, admittedly, personal and professional experience—but not empirical research. And that is despite the fact that sports have generally moved to analytic-based management models (Ricky, 2019). Therefore, there is a pressing need for empirical research to help guide future sports production practices. For scholars, this type of research can also lead to mass communication theory development, as these types of production phenomena raise questions about the underlying theoretical causes.

As entertainment programming, sports serve an important social role (Serazio, 2019) and they fulfill their role via in-person spectating and mediated sports broadcasts. Indeed, sport and media, including broadcast, are so intrinsically interdependent (Greer et al., 2009) that change in either industry is likely to affect the other, and both have a significant impact on the American economy and society (e.g., Au, 2017; Goldman & Hedlund, 2020). During the 2020 COVID-19 pandemic, mediated sports broadcasts were often the only connection between sports fans and the events, as spectators were either not allowed into the venues, or allowed in very limited numbers. That same year, Coche and Lynn (2020) called for more practical research in sports broadcasting. They argued it "should be conducted as soon as possible" (p. 492) because the lockdown-caused decrease in production quality in early 2020 lowered audiences' expectations, which gives broadcasters "a free pass" (p. 489) to change the traditional workflow in live sports productions. This argument can be extended to other deep-rooted conventions and techniques, such as camera angles during live games. This study is a response to Coche and Lynn's (2020) call. With sports broadcasting going through "drastic changes" (p. 492), studying the effects of new camera angles on viewers' ability to understand what they are watching could directly guide the development of new production practices in the post-COVID sports broadcast world. The sports lockdown in 2020 reminded people how important sport is in American society (Coche & Lynn, 2020; Goldman & Hedlund, 2020). When NBC Sports used the Skycam, executive producer Sam Flood announced the network was planning on increasing the use of the angle over time (Deitsch, 2018), but that has not happened in practice—presumably because of negative social media reactions to the use of the novel angle. However, because the industry is rapidly adopting new technology (Coche & Lynn, 2020; Davies, 2020; Werteen, 2020), conducting research on production techniques used only temporarily, like the Skycam angle for play-by-play coverage, can help broadcasters as they lead the way to adapt their practices for the viewers. It also informs future research about audience members' complaints when a novel production approach is introduced. At times, the viewer experience can be a two-way negotiation between production personnel and the viewers; research exploring the outcomes of attempted production changes, and underlying causes for failed change, can inform future production decisions.

Literature Review

Previous scholars have called sport broadcasts "artificial creations" that, by nature, "result from a variety of production decisions aimed at increasing their entertainment value" (Cummins et al., 2019, p. 113). The visual element of these broadcasts is of particular importance (Greer et al., 2009). When watching football, some rely on yardage lines painted on the field to estimate how much yardage was gained. The lines certainly provide a robust linear perspective (Kubovy, 1986). The Madden camera adds several unique visual depth cues to that, including (1) line convergence, which provides viewers with a sense of depth through the distant merging of the painted lines and the field itself (Figure 1); (2) perspective geometry, which communicates to the viewer which player on the screen is farther from them; and (3) size constancy (Gibb et al., 2010), which allows viewers to determine the distance from one object to another (the farther the object, the smaller it appears). These visual cues imply the Madden camera is more accurate than the traditional camera, but other factors must be considered.

Just prior to the snap of the ball, the initial image composition of the Madden camera provides a narrower image space from which to make yardage estimations (Figure 2). From the traditional game camera angle, 10 yards covers approximately 800 pixels, but the same 10 yards need only a quarter of that space (about 200 pixels) with the Madden camera angle. That difference might partially explain viewers' negative reactions: despite the Madden camera's

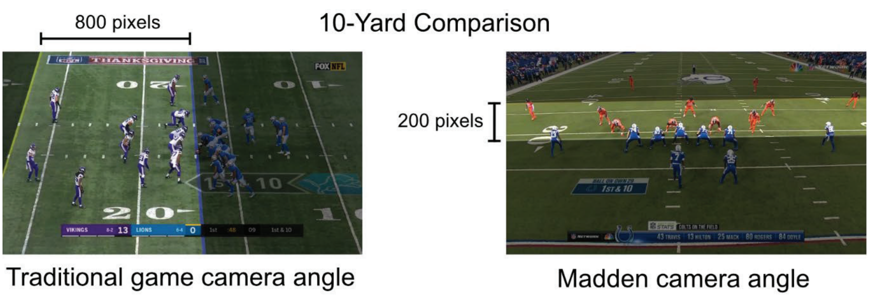

Figure 2. At the snap of the ball in these 1920 x 1080-pixel broadcasts, 10 yards used approximately 42% of the horizontal space from the traditional game camera and 19% of the vertical space from the Madden camera. Measurements are approximate because camera positions and framing can vary slightly with each play.

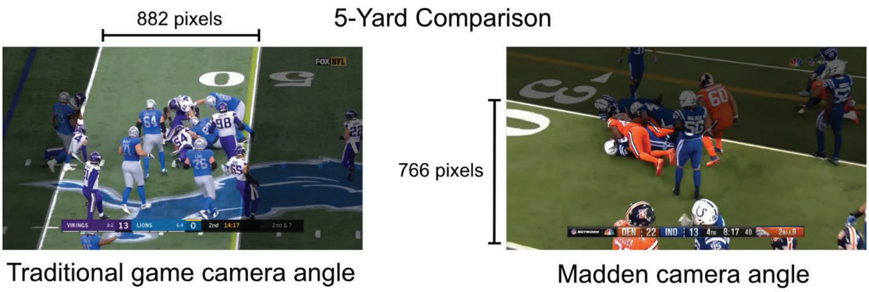

Figure 3. At the time the ball hits the ground on these five-yard running plays, five yards used approximately 46% of the horizontal space from the traditional game camera and 71% of the vertical space from the Madden camera.

additional depth perception cues, estimating depth based on 200 pixels may be more difficult than doing so based on 800 pixels. Both cameras provide similar ending compositions, with the Madden camera utilizing a greater percentage of the vertical space than the traditional camera's horizontal space (Figure 3).

When a viewer attempts to estimate the yardage gained from the line of scrimmage, regardless of whether the ball is thrown or run, they make an estimation using visual strategies, which have been shown to be key factors in visual perception (Van der Ham & Borst, 2011). A visual strategy might involve watching where the ball stops and using the one-yard and five-yard marks on the field to estimate how far the ball traveled. Another visual strategy might involve using the first-down marker on the sideline, a known distance of 10 yards, and estimating how far the ball was from the mark, then subtracting the estimated distance from 10 to calculate how far the ball traveled on a first down. Yet another strategy could be estimating visual distance based on how far the ball stops from the end zone when it is visible. Hence, reliance on the visual perception literature will help establish if the viewers' negative reactions to the Madden camera were based on objective visual differences, or another social cognitive phenomenon. Visual perception has been one of the most influential areas of science for centuries (Al-Haytham, 1989) and it remains at the forefront (Cavanagh, 2011; Linton, 2017; Tulver, 2019). Depth perception and distance estimations are particularly valuable because of their practical applications, such as piloting aircraft (Gibb et al., 2010) or improving military efficiency (Gibson & Bergman, 1954), and football broadcasts may be an appropriate addition to the study of visual perception because the audience is naturally making yardage estimations based on visual information.

Studying visual perception is also important to sports broadcasters because exceeding the viewers' limits of visual perception capabilities will upset the audience and negatively affect ratings, which risks upsetting leagues and advertisers, both of whom are essential for broadcasters to remain profitable (Evens et al., 2013). In other words, a simple change in the production of football broadcasts could create a chain effect with severe economic implications.

Hypotheses and Research Question

Because broadcasters normally use the traditional game camera angle for live play-by-play coverage, participants are expected to have more practice estimating distance from the traditional game camera than from the Madden camera:

H1: Participants will make yardage estimates more accurately from the traditional game camera angle than from the Madden camera angle for running and passing plays.

Additionally, because visual perception develops over time (Tulver, 2019), those who watch football habitually are expected to make more accurate estimations than those who do not:

H2: Participants' football-viewing habits will predict the accuracy of their yardage estimations from the game camera angle for running and passing plays.

Though football-viewing habits are expected to give participants an accuracy advantage from the traditional game camera, it is unclear whether it will translate into more accurate yardage estimations from the Madden camera because of the novelty of that camera angle. Therefore, a research question is proposed:

RQ1: Will participants' general football-viewing experience predict the accuracy of their yardage estimations from the Madden camera for running and passing plays?

With *Madden* holding a prominent position in video gaming and sports cultures (Dougherty, 2017), the game may have measurable effects on players. If the *Madden* video game camera angle closely mirrors the real-life camera, then *Madden* players generally should have more practice making distance estimations since visual perception skills can improve with practice (Gibb et al., 2010), therefore:

H3: Participants who identified themselves as *Madden* players will estimate yardage gains significantly better than participants who do not play Madden from the Madden camera angle for running and passing plays.

Finally, if participants become more accurate with practice (Tulver, 2019), then:

H4: Participants' *Madden* NFL gaming habits will predict the accuracy of their yardage estimations from the Madden camera angle for running and passing plays.

Method

Using a between-subjects design, participants ($N = 473$) were randomly assigned to watch 11 football plays (four running plays and seven passing plays) from either the traditional game camera angle ($n = 236$) or the Madden camera angle ($n = 237$). Participants watched 11 plays exclusively from one of the camera angles, not both. Eleven plays were used to ensure a large data set, give participants multiple opportunities to make estimations, and cover various yardage gains that would be common in a football game. That included short and long runs (5 and 10 yards) and short, medium, and long passes (from 3 to 20 yards). The total yardage was equal for each camera angle and plays in both conditions were shown in random order.

Stimulus Creation

Criteria for plays to be included were (1) they did not result in a touchdown, (2) they resulted in positive yardage for the offense, (3) the yellow first-down line was visible, and (4) plays were outside of the red zone (i.e., the area of the field between the 20-yard-lines and the goal lines) to avoid additional visual perception cues like the end zone. Four NFL games were used to produce the stimuli: two TNF games for the Madden camera angle, and two regular season Sunday games for the traditional game camera angle. Clips from each angle were paired according to play type and yardage gains.

After identifying plays for inclusion, the audio was removed to ensure all participants took the survey based on the same content (regardless of whether their audio was on or off). Each video started three seconds before the ball was snapped and ended two seconds after the play was whistled dead, giving participants enough time to process the activity in the clip while keeping broadcaster graphics from revealing the yardage gained. Pretesting ($n = 57$) found no indication that the editing of the clips influenced participants' abilities to make yardage estimations.

Measures

Participants estimated the yardage gained after watching each play, using a slider ranging from 0 to 35 yards. The participants' total yardage for all plays was summed to provide a Total Yardage estimate. Estimates from the four running plays and seven passing plays were summed to provide estimates for Total Running Yards and Total Passing Yards, respectively. After watching and estimating yardage from all 11 clips, a single, five-point Likert scale asked participants to rate their confidence in the yardage estimations they had made.

Then participants used a three-item scale adapted from a Limelight Networks video gaming study to assess their football-viewing habits. Participants (*n* = 470) self-reported on a seven-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree" (1) I often watch more than one football game per week during the season, (2) I adjust my normal routine to accommodate watching football, and (3) I often watch more than six hours of football per week, including NFL Red Zone and Game Pass. An exploratory factor analysis revealed a single factor solution with all loadings scoring greater than .85. The three items were internally consistent as an index (Cronbach's Alpha = .93). Based on the same Limelight Networks video gaming report, a three-item scale was created to measure participants' *Madden NFL* gaming habits. Using skip logic within the survey, participants were asked if they play the *Madden* video game. Those who identified themselves as *Madden* players (*n* = 147) self-reported on the same seven-point Likert scale (1) playing *Madden* is part of my regular gaming routine, (2) I invest extra hours playing when a new *Madden* game drops, and (3) I often spend more than one hour a week playing *Madden*. A similar exploratory factor analysis showed a single factor solution that was consistent as an index (Cronbach's Alpha = .88).

Finally, two single-question attention checks were incorporated into the study—one after the informed consent and one between the yardage estimations and the questions about football viewing and *Madden*-gaming habits.

Sampling

Amazon Mechanical Turk was used for the participant pool because it provided a representative sample of a typical NFL audience. About 38% of "avid" NFL fans are women (Graham & Young, 2020) and 33% (*n* = 155) of our participants were women. Additionally, the league's key ratings demographics are people aged 18–54 (Sports Media Watch, 2020) with a median of 36, while our participants' median age was 34 and their average age was 37.05 (*SD* = 11.69). Participants were paid $1 to participate and completing the survey took approximately eight minutes. Three pretests were conducted (*n* = 9 for each) to fix any technical or methodological problems identified before the study was launched at scale. Overall, 595 responses were collected for the study, but 122 responses were excluded from analysis because of failed attention checks (*n* = 7), making less than six estimations (*n* = 67), using a mobile device (*n* = 19), and having responses more than three IRQ outside the range of normal values (*n* = 29).

Participants

Participants in the final data set (N = 473) were 37 years old (SD = 11.69), about 67% male (n = 316), 33% female (n = 155), with two participants identifying as *Other*. They watched an average of 8.81 hours of football during the football season (SD = 2.06), 6.12 hours of sports on traditional television per week (SD = 6.42), and 3.48 hours of sports online per week (SD = 5.50). They watched sports with other people (M = 1.68, SD = 1.57), and were *fairly confident* to *confident* about the estimations they provided (M = 3.45 out of 5, SD = 1.01). Across all conditions, participants who played *Madden NFL* (n = 147) played an average of 9.67 hours per week (SD = 11.75), scored 4.60 out of 7 on the *Madden*-gaming habits scale (SD = 1.51), and each participant averaged 1,193.24 total hours playing the game (SD = 1,253.32). Of the *Madden* players randomly assigned to the Madden camera angle condition (n = 71), they played an average of 8.0 hours per week (SD = 10.6), averaged 1,311.76 total hours playing the game (SD = 1,355.49), and scored a 4.61 out of 7 on the *Madden* scale (SD = 1.41).

Missing Estimates

When participants failed to make a yardage gain estimation before the countdown timer expired, the estimate was missing from the participants' data. Because the analysis was based on total yardage estimates and because preliminary analysis showed estimates were higher than the actual yardage gained, a missing estimate would have positively impacted the accuracy of participants' overall estimates (Table 1). To address this and make each participant's total more reflective of their actual abilities, the mean yardage estimate was calculated for each video and used in place of the missing estimates. In total, 97 participants missed one estimation, 26 missed two, 15 missed three, seven missed four, and two missed five. Those who failed to make six or more (out of 11) estimations were eliminated from the data set. The final data set contained 232 estimations replaced with mean scores and 4,971 completed estimations (a 95.54% overall completion rate). Because participants were randomly assigned to the conditions and because the stimuli in each condition were randomly presented, missing estimations did not significantly influence any single estimation. As a confirmatory measure, the data were also analyzed excluding the participants who had missed estimations and no significant differences were found in the results. Therefore, the estimates with missing estimations were included to improve the ecological validity of the study, as network sports broadcasters expect minimum sample sizes of roughly 500 participants in research designs.

Results

The total yardage of the four running plays was 25 yards and the total yardage of the seven passing plays was 64 yards; the cumulative yardage from each camera angle was 89 yards (Table 1). Participants' estimations were generally higher than the objective yardage with large standard deviations, indicating that participants poorly estimated distance. This has real-life applicability as broadcasters cannot expect the average audience member to be trained to estimate yardage. The high variances—present for both camera angles—show that American football is a very complex game to visually follow.

Table 1. Camera Angle Yardage Estimates

	Game camera ($n = 236$)			Madden camera ($n = 237$)			
Play Type	Mean	SD	Variance	Mean	SD	Variance	Play Type
5-yard run A	6.91	4.01	16.06	6.89	4.30	18.52	5-yard run A
5-yard run B	6.78	4.56	20.80	7.87	4.65	21.60	5-yard run B
5-yard run C	6.38	4.49	20.12	7.90	4.77	22.74	5-yard run C
10-yard run	12.62	4.54	20.61	11.93	4.23	17.88	10-yard run
3-yard pass	5.77	4.29	18.42	6.01	5.44	29.63	3-yard pass
4-yard pass	5.77	4.23	17.86	6.70	4.47	19.98	4-yard pass
6-yard pass	7.61	4.24	17.95	8.94	4.36	18.99	6-yard pass
7-yard pass A	8.88	4.97	24.72	9.65	5.55	30.80	7-yard pass A
7-yard pass B	9.84	5.44	29.65	10.44	5.20	27.03	7-yard pass B
17-yard pass	17.89	5.01	25.07	19.30	6.19	38.31	17-yard pass
20-yard pass	20.75	5.62	31.56	18.78	5.51	30.35	20-yard pass
				ESTIMATED YARDAGE TOTALS			
							Actual yardage
Running plays	31.51	12.98	168.59	33.21	13.85	191.79	25
Passing plays	73.62	19.76	390.60	75.51	24.27	589.27	64
Total yardage	105.13	29.86	891.87	108.72	34.12	1168.01	89

Note: Play type is listed twice to indicate that the stimuli for the two conditions had equal yardage gains but the footage came from different NFL games.

Camera Angles

H1 predicted that participants would estimate yardage significantly more accurately from the game camera angle than from the Madden camera angle for running and passing plays. A two-way MANOVA showed no significant differences between the two angles for either running (Madden camera: *M* = 33.21, *SD* = 13.85; game camera: *M* = 31.51, *SD* = 12.98) or passing plays (Madden camera: *M* = 75.51, *SD* = 24.27; game camera: *M* = 73.62, *SD* = 19.76) ($F(2, 470) = 1.44$, $p = .24$; Pillai's Trace = .01; partial $\eta^2 = .01$). It should be noted that Levene's Test of Homogeneity of Variance showed homogeneity of variance for running plays ($p = .19$) but not for passing plays ($p < .01$).

Football-Viewing Habits

H2 predicted that as participants' football-viewing habits increased, the accuracy of their yardage estimations from the game camera angle would improve for running and passing plays. A simple linear regression showed football-viewing habits significantly, positively predicted yardage estimations of running plays, $F(1, 234) = 4.25$, $p = .04$, and accounted for approximately 2% of the variance, with adjusted $R^2 = .01$ (Table 2), but did not predict estimations of passing yardage, $F(1, 234) = .02$, $p = .90$. While football-viewing habits significantly predicted yardage estimations of running plays, the correlation was positive, meaning that as a participants' football-viewing habits increased, their estimations became significantly worse. H2 had predicted a negative correlation, hence it was not supported.

RQ1 asked if participants' football-viewing habits might predict the accuracy of their yardage estimations from the Madden camera angle ($n = 237$) for running and passing plays. A simple linear regression revealed football-viewing habits did not significantly predict the accuracy of running yardage estimations, $F(1, 235) = .10$, $p = .75$, or passing yardage estimations, F(1, 235) = .41, p = .53 (Table 2). Consequently, football-viewing habits did not predict the accuracy of the participants' yardage estimations from the Madden camera.

Madden-Gaming Habits

H3 predicted that participants who played *Madden* would make more accurate yardage estimations from the Madden camera angle ($n = 237$) for running and passing plays than those who did not play *Madden*. Descriptive statistics showed that participants made higher yardage estimations if they were *Madden* players ($n = 71$) for both running plays (*M* = 37.67, *SD* = 17.75) and passing plays (*M* = 81.18,

Table 2. Predictors of Total Running and Passing Yards

Predictor	Condition	*n*	*B*	*S.E.*	*β*	R^2	ΔR^2
Passing Yards							
Football-Viewing Habits	Game Camera	236	.86	.42	.13*	.02	.01
Football-Viewing Habits	Madden Camera	237	.14	.44	.02	.02	-.004
Madden-Gaming Habits	Madden Camera	71	1.71	1.50	.14	.14	.004
Running Yards							
Football-Viewing Habits	Game Camera	236	.08	.65	.01	.01	-.004
Football-Viewing Habits	Madden Camera	237	-.49	.77	-.04	.04	-.003
Madden-Gaming Habits	Madden Camera	71	1.95	2.30	.10	.10	-.004

Note: * $p < .05$.

SD = 27.04) compared to non-*Madden* players ($n = 166$; $M = 33.27$, $SD = 11.68$; $M = 79.23$, $SD = 23.47$) (Table 3). Both groups over-estimated yardage gains. A two-way MANOVA showed differences between the participant type on the combined dependent variables was statistically significant, $F(2, 234) = 3.42$, $p = .04$; Pillai's Trace = .03; partial $\eta^2 = .03$. It should be noted that Levene's Test of Homogeneity of Variance did not show homogeneity of variance for running plays ($p < .001$) but did for passing plays ($p = .06$). Follow-up univariate ANOVAs showed that the difference between those who played Madden and those who did not was statistically significant on running plays—though the difference was typically around one yard only ($F(1, 235) = 5.09$, $p = .03$; partial $\eta^2 = .02$), but not passing plays ($F(1, 235) = .32$, $p = .58$; partial $\eta^2 = .01$). Since Madden NFL players made significantly worse yardage estimations for running plays compared with non-Madden players, and no difference was found on passing plays, H3 was not supported.

H4 anticipated that participants' ($n = 71$) *Madden*-gaming habits would predict the accuracy of their estimations from the Madden camera angle for running and passing plays. A simple linear regression showed *Madden*-gaming habits did not significantly predict yardage estimations of either running plays, $F(1, 69) = 1.29$, $p = .26$, or passing plays $F(1, 69) = .72$, $p = .40$ (Table 2), so H4 was not supported.

Discussion

When NBC Sports decided to use the Madden camera for live football games, some viewers took to social media to complain about how difficult it was to determine the yardage gained on each play (Adamski, 2017; Andrews, 2017; Gaines, 2017;

Table 3. Estimations from the Madden Camera Angle

	Plays *Madden NFL* (*n* = 71)			Does Not Play *Madden NFL* (*n* = 166)			
Play Type	Mean	SD	Variance	Mean	SD	Variance	Play Type
5-yard run A	7.74	5.67	32.15	6.52	3.52	12.40	5-yard run A
5-yard run B	8.55	5.84	34.10	7.58	4.02	16.13	5-yard run B
5-yard run C	8.42	5.37	28.81	7.67	4.49	20.12	5-yard run C
10-yard run	12.95	4.91	24.14	11.50	3.83	14.70	10-yard run
3-yard pass	6.47	6.32	39.98	5.82	5.03	25.30	3-yard pass
4-yard pass	7.46	5.35	28.58	6.37	4.01	16.09	4-yard pass
6-yard pass	9.07	5.15	26.52	8.88	3.99	15.90	6-yard pass
7-yard pass A	9.84	5.88	34.56	9.57	5.42	29.36	7-yard pass A
7-yard pass B	10.78	5.47	29.89	10.30	5.09	25.90	7-yard pass B
17-yard pass	18.64	5.49	30.19	19.58	6.46	41.72	17-yard pass
20-yard pass	18.92	5.47	29.88	18.72	5.54	30.71	20-yard pass
ESTIMATED YARDAGE TOTALS							
							Actual yardage
Running plays	36.44*	17.44	304.25	31.83*	11.78	138.84	25
Passing plays	76.34	25.37	643.71	75.16	23.86	569.33	64
Total yardage	112.77	38.65	1494.21	106.99	32.04	1026.70	89

Note: * $p < .05$.

Seifert, 2017). The present study explored that phenomenon in order to (1) provide data to broadcasters so they can make decisions based on empirical evidence rather than their best guesses or feelings—as was the case when networks decided whether to add artificial audio to their broadcasts when stadiums were empty (Bose, 2020) and (2) inspire other practice-based research.

Camera Angles

The driving research question asked if the Madden camera was less accurate for yardage estimations than the traditional game camera. Results showed the yardage estimations from the two camera angles were statistically similar, which raises interesting questions about viewer complaints and how we interpret and explain them. The high variance in the estimations showed those who complained were probably correct: making yardage estimations from the Madden camera angle was a difficult task. However, the study made a novel discovery, finding that people's estimates are just as inaccurate when watching the traditional game camera. In other words, for every participant who had difficulty making yardage estimations from the Madden camera, another participant struggled doing so from the traditional game camera.

One explanation for the difficulty in making estimations lies in the high demand on working memory and attention required regardless of the camera angle. Working memory is a limited resource and it focuses attention on only one item at a time in visual perception (Thigpen et al., 2019). So, the recall required to remember the starting point of the ball, while also trying to follow where the ball stops, makes estimations difficult. If the participants relied on visible yardage markers as cues, then they had a difficult time making estimations from either camera as it zoomed in (Figures 3 and 4).

While visual perception literature may explain the non-significant differences between the angles, it does not explain why viewers became vocal on social media about the production changes. A social scientific approach to the problem is necessary: after more than 50 years of football broadcasts, networks have cultivated (Gerbner & Gross, 1976; Shanahan & Morgan, 1999) viewers' expectations such that deviations from the anticipated structure can create negative experiences for the viewers (Coche & Lynn, 2020), no matter whether objective differences in visual perception exist. Continuing to test the theoretical underpinnings of the phenomenon is relevant to the sport industry because those findings could guide future production changes in ways that minimize negative viewer reactions. Scholars should collaborate with broadcasters to examine the problem from multiple perspectives and ensure that research designs have applicability outside of media labs.

Football-Viewing Habits

This study also examined the possible influence of football viewing on yardage estimations. Viewers who watch more football were expected to make more accurate estimations from the game camera angle, but they did not. Similarly, in response to RQ1, participants' football-viewing habits did not influence their ability to make yardage estimations from the Madden camera. In short, how much a participant watched football had no significant impact on the yardage estimations they made. Both the camera angles and football-viewing habits results point toward the importance of commentary and artificial intelligence (AI; like added graphics) to help the audience understand the action in a football game. As Narraine and Wanless (2020) concluded, AI contributes greatly to sport consumers' experiences.

These results might be explained by the way visual perception training was operationalized in the study. An underlying assumption of the study was that watching football provides people experience at estimating yardage. The results did not align with that assumption, indicating that watching football alone is probably not a form of visual training that has a meaningful impact on improving yardage estimations. Rather, improving estimations probably requires a more intentional form of training where viewers are taught to use visual cues in the image, such as the yardage markers and the first-down line. Future research should explore the types of training environments and instructional methodologies that could lead to more accurate yardage estimations.

Madden-Gaming Habits

Another underlying assumption of the study was that *Madden* provided gamers with additional practice at making yardage estimations from the real-life *Madden* camera. If the visual perception literature was correct, and practice could improve one's visual perception (Gibb et al., 2010; Linton, 2017; Tulver, 2019), it followed that *Madden* players would make more accurate estimations. Again, the analysis found no significant differences between the groups for passing plays, and Madden players made significantly worse estimations for running plays; another novel finding of the study. This demonstrates the need to question and systematically test commonly held beliefs about sport audiences.

Limitations

Though this study provides notable implications for scholars and practitioners, it also has limitations. First, internal validity was limited because the study was designed to provide a look at possible differences between real-world viewers under real-world viewing conditions. Under strictly controlled experimental conditions, significant differences between the two camera angles might have been found. This possibility should certainly be tested in future replications. The focus on external validity should be considered a valid reflection of how difficult it is for average viewers to make accurate yardage estimations when they have been provided with minimal instructions and no pre-training or prior practice. The high variance in the participants' estimations could also be perceived as a limitation, but the results were in line with outcomes from previous applied visual perception research that found that estimations vary widely across individuals (Gibson & Bergman, 1954) and spatial processing requires a range of skills to make accurate holistic judgements (Ullman, 1996). Therefore, the variance is likely attributable to the difficulty of estimating yardage for average viewers.

Conclusion

Scholars have predicted the post-COVID sports broadcast world could look different from what it was pre-COVID, in terms of content (Binganam, 2020; Goldman & Hedlund, 2020) and workflow (Coche & Lynn, 2020). The COVID-19 pandemic serves as a reminder of the importance of sport in society (Coche & Lynn, 2020; Goldman & Hedlund, 2020), and, by extension, the importance of sports communication research for society. Conducting practical research now is all the more relevant as the media industry is experiencing an accelerated adoption of new technology and production changes as a result of the pandemic (Coche & Lynn, 2020; Davies, 2020; Werteen, 2020). This study's findings challenge our understanding of camera angles and the effects of playing video games, indicating that more scientific research in sports broadcast practices is necessary so practitioners can make evidence-based decisions. Fundamentally, this study shows that watching an American football broadcast is a visually challenging experience that is likely facilitated through announcer commentary and artificial intelligence (mainly in-game graphics).

References

Adamski, C. (2017, November 17). NBC, NFL noncommittal on future SkyCam usage. *Trib Live*. https://archive.triblive.com/sports/steelers/nbc-nfl-noncommittal-on-future-skycam-usage/

Al-Haytham, I. (1989). *The optics of Ibn Al-Haytham books I-III.* (A. I. Sabra, Trans.). The Warburg Institute, University of London. (Original work published in 1024).

Andrews, T. M. (2017, November 17). NFL's Thursday Night Football looked like a video game. Plenty of fans didn't like it. *The Washington Post*. https://www.washingtonpost.com/news/morning-mix/wp/2017/11/17/nfl-fans-are-arguing-again-its-not-about-kneeling-but-a-camera/

Au, T. (2017, October 13). As remarkable growth of sports industry continues, exclusive data analysis reveals the key trademark trends. *Lexology*. https://www.lexology.com/library/detail.aspx?g=18a78c6e-4ee9-444c-8889-a039583c54a7

Bose, O. (2020, Dec. 15). Inside the NFL 2020 [Virtual conference session]. Sports Video Group Annual Summit. https://www.thesvgsummit.com/

Cavanagh, P. (2011). Visual cognition. *Vision Research, 51*(13), 1538-1551. https://doi.org/10.1016/j.visres.2011.01.015

Coche, R., & Lynn, B. J. (2020). Behind the scenes: COVID-19 consequences on broadcast sports production. *International Journal of Sport Communication, 13*(3), 484-493. https://doi.org/10.1123/ijsc.2020-0231

Cooper, G. F. (2017, November 17). NFL's first 'Madden Cam' game racks up fans and foes. *CNet*. https://www.cnet.com/news/nfl-madden-cam-thursday-night-football-skycam-steelers-titans/

Cummins, R. G., Berke, C. K., Moe, A., & Gong Z. (2019). Sight versus sound: The differential impact of mediated spectator response in sport broadcasts. *Journal of Broadcasting & Electronic Media, 63*(1), 111-129. https://doi.org/10.1080/08838151.2019.1568806

Davies, M. (2020, Dec. 14). The national network town hall [Virtual conference session]. Sports Video Group Annual Summit. https://www.thesvgsummit.com/

Deitsch, R. (2018, September 4). Part II of the NFL broadcast guide: Taking a look at ESPN, NBC, and the NFL Network. *The Athletic*. https://theathletic.com/504082/2018/09/04/part-ii-of-the-nfl-broadcast-guide-taking-a-look-at-espn-nbc-and-the-nfl-network/

Dougherty, J. (2017, October 5). 'Don't you play Madden?' Video games are creating smarter youth football players. *The Washington Post*. https://www.washingtonpost.com/sports/dont-you-play-madden-video-games-are-creating-smarter-youth-football-players/2017/10/05/37aed9cc-a46d-11e7-8c37-e1d99ad6aa22_story.html

Evens, T., Iosifidis, P., & Smith, P. (2013). *The political economy of television sports rights*. Palgrave MacMillan.

Gaines, C. (2017, December 17). 3 plays that show perfectly why Skycam is the future of the NFL on TV. *Business Insider*. https://www.businessinsider.com/nfl-skycam-thursday-night-football-2017-12

Gerbner, G., & Gross, L. (1976). Living with television: The violence profile. *Journal of Communication, 26*(2), 173-199. https://doi.org/10.1111/j.1460-2466.1976.tb01397.x

Gibb, R., Gray, R., & Scharff, L. (2010). *Aviation visual perception*. Routledge.

Gibson, E. J., & Bergman, R. (1954). The effect of training on absolute estimation of distance over the ground. *Journal of Experimental Psychology, 48*(6), 473-482. https://doi.org/10.1037/h0055007

Goldman, M. M., & Hedlund, D. P. (2020). Rebooting content: Broadcasting sport and esports to homes during COVID-19. *International Journal of Sport Communication, 13*(3), 370-380. https://doi.org/10.1123/ijsc.2020-0227

Graham, M., & Young, J. (2020, Feb. 2). Women are watching the NFL in record numbers, and Super Bowl ads are finally starting to reflect that. *CNBC*. https://www.cnbc.com/2020/02/01/women-nfl-fans-are-at-a-record-and-super-bowl-ads-finally-reflect-that.html

Greer, J. D., Hardin, M., & Homan, C. (2009). "Naturally" less exciting? Visual production of men's and women's track and field coverage during the 2004 Olympics. *Journal of Broadcasting & Electronic Media, 53,* 173-189. https://doi.org/10.1080/08838150902907595

Kempner, A. (2021, February 17). Sports production tools: A virtual forum. *Sports Video Group.* https://youtu.be/cQqLXmy49og?t=1025

Kubovy, M. (1986). *The psychology of linear perspective and Renaissance art.* Cambridge University Press.

Limelight Networks. (2018). The state of online gaming – 2018. *Limelight Networks*. https://www.limelight.com/resources/white-paper/state-of-online-gaming-2018/

Linton, P. (2017). *The perception and cognition of visual space.* Palgrave Macmillan.

Malyon, E. (2017, November 17). The story behind Skycam—How a foggy day and a computer game may have changed sports broadcasting forever. *Independent*. https://www.independent.co.uk/sport/us-sport/national-football-league/skycam-nfl-highlights-thursday-night-football-nbc-cbs-fox-sports-pittsburgh-steelers-tennessee-a8060716.html

Narraine, M. L., & Wanless L. (2020). Going all in on AI. *Sport Innovation Journal, 1,* 49-61. https://doi.org/10.18060/23898

Ricky, A. (2019, January 31). How data analysis in sports is changing the game. *Forbes*. https://www.forbes.com/sites/forbestechcouncil/2019/01/31/how-data-analysis-in-sports-is-changing-the-game/?sh=755dfab13f7b

Ruiz, S. (2017, October 23). The Patriots-Falcons fog game revealed we've been watching the NFL from the wrong angle. *USA Today*. https://www.theringer.com/nfl/2017/10/22/16518688/new-england-patriots-atlanta-falcons-fog-bowl

Seifert, K. (2017, November 22). SkyCam unlikely to catch on as the primary NFL view. ESPN. com. http://www.espn.com/blog/nflnation/post/_/id/258540/skycam-unlikely-to-catch-on-as-the-primary-nfl-view

Shanahan, J., & Morgan, M. (1999). *Television and its viewers: Cultivation theory and research*. Cambridge University Press.

Sports Media Watch. (2020). NFL TV ratings page. *SMW.* https://www.sportsmediawatch.com/nfl-tv-ratings-viewership-2020-2019/

Thigpen, N., Petro, N. M., Oschwald, J., Oberauer, K., & Keil, A. (2019). Selection of visual objects in perception and working memory at a time. *Psychological Science, 30*(9), 1259-1272. https://doi.org/10.1177/0956797619854067

Tulver, K. (2019). The factorial structure of individual differences in visual perception. *Consciousness and Cognition, 73,* Article 102762. https://doi.org/10.1016/j.concog.2019.102762

Ullman, S. (1996). *High-level vision*. MIT Press.

Van der Ham, I. J. M., & Borst, G. (2011). Individual differences in spatial relation processing: Effects of strategy, ability, and gender. *Brain and Cognition, 76*(1), 184-190. https://doi.org/10.1016/j.bandc.2011.01.008

Werteen, M. (2020, Dec. 15). The remote production services town hall [Virtual conference session]. Sports Video Group Annual Summit. https://www.thesvgsummit.com/