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Manuscript

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Michael Christian Leitner ^{1,2}
<https://orcid.org/0000-0002-9341-854X>

Fabio Richlan ^{1,2}
<https://orcid.org/0000-0001-5373-3425>

¹ Centre for Cognitive Neuroscience (CCNS), University of Salzburg, Austria

² Department of Psychology, University of Salzburg, Austria

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Corresponding author: Michael C. Leitner / University of Salzburg / Centre for Cognitive
Neuroscience / Department of Psychology / Hellbrunnerstrasse 34 / 5020 Salzburg / Austria
michaelchristian.leitner@sbg.ac.at

Abstract

Introduction. Due to the COVID-19 pandemic, European elite football (soccer) leagues played the remaining season 2019/20 without or strongly limited attendance of supporters (i.e., “ghost games”). From a psychological perspective this situation poses a unique opportunity to investigate the crowd’s influence on referee decisions and the associated effect of “home advantage”.

Methods. A total of 1286 matches - played in the top leagues of Spain, England, Germany, Italy, Russia, Turkey, Austria and the Czech Republic - were analyzed for results, fouls, bookings and reasons for bookings and contrasted between respective matchdays of season 2018/19 (regular attendance) and season 2019/20 (ghost games).

Results. There are two main findings. First, the overall home advantage effect in the respective elite leagues - identified in the respective matches of the regular 2018/19 season – vanished in the ghost games of the 2019/20 season. Consequently, home teams lost significantly more matches, whereas away teams won significantly more matches. Second, only home teams were booked significantly more often with yellow cards for committing fouls in ghost games. Most importantly, our analysis provides evidence that this effect was independent of the course of the games. In contrast, bookings for other reasons (criticism and unfair sportsmanship) changed similarly for both home and away teams in ghost games.

Conclusion. We conclude that the lack of supporters in top European football during the COVID-19 pandemic led to decreased social pressure from the ranks on referees. This implication is consistent with previous research in smaller size and experiments in artificial settings. As a result of decreased social pressure, referees assessed the play of home teams more objectively, which further led to increased yellow cards awarded for fouls committed by the home teams. Since there were no significant changes in referee decisions against the away teams, we argue that our observations in ghost games reflect a reduction of unconscious favoritism of referees for the home teams. This key finding provides a firm empirical basis for the development of novel methods - such as virtual reality interventions - for training referees and thus minimizing the effects of decisions made under social pressure.

Introduction

Due to the COVID-19 pandemic, European top football (soccer) leagues paused competition around the middle of March 2020. The first league to restart was the "German Bundesliga" on May 16th. Ultimately, 11 of 15 European's top leagues resumed competition and finished the season (Spain, England, Germany, Italy, Portugal, Russia, Ukraine, Turkey, Austria and Czech Republic). France, Belgium, Netherlands and Scotland suspended their leagues and aborted ("ORF Sport. Frühlingserwachen in Europas Ligen," 2020; "Spiegel Sport. So planen Europas Fussballligen den Neustart," 2020).

The fundamental requirement for restarting competition was to play matches without the attendance of supporters; so-called "ghost games". Only the Russian league chose to let a limited number of supporters - 10% of each stadium's capacity - attend matches (MDZ. Im Alleingang gegen die Geisterspiele," 2020). From a psychological perspective, the circumstance of missing supporters on this unprecedented large scale in Europe's elite football leagues poses a unique situation in the history of professional football to investigate the crowds' influence on referees' decisions.

The effect of home advantage is a well-documented effect in professional sports. Allen and Jones (2014) state that "[...] *a large body of research has confirmed that athletes and teams perform considerably better when they compete at home compared with away from home.*" (p.48). Courneya and Carron (1992) define home advantage as "[...] *the term used to describe the consistent finding that home teams in sport competitions win over 50% of the games played under a balanced home and away schedule.*" (p.13). Accordingly, Jamieson found in a meta study across sport disciplines that home teams win significantly more often than away teams (Jamieson, 2010). Pollard, Prieto & Gómez (2017) find the biggest home advantage effects in basketball (60.13%), followed by Handball (59.26%), Rugby union (57.93%), Bandy (57.51%), Volleyball (56.62%) and Football (56.54%).

In the scientific literature, there is strong support for the hypothesis that the home advantage can be largely explained by social pressure on the referees, emanating from the present audience, attributed to the noise the crowd produces in favor of the home team during games. Questions such as whether referees tend to favor the home team or disadvantage the away team are still subject of ongoing discussions (Pollard, 2008). From psychological and evolutionary perspectives, an explanation for the home advantage effect, based on social pressure and conformity are logical and comprehensible. Social psychological studies indicate that human beings tend to adapt to the opinion of the majority because individuals (unconsciously)

believe that a group's interpretation of an ambiguous situation is more accurate than their own, ultimately leading to conform behavior (Cialdini & Goldstein, 2004). Accordingly, studies found that crowd size (Nevill, Newell & Gale, 1996), crowd density (Agnew & Carron, 1994; Goumas 2012) and stadium properties (distance to the field) (Unkelbach & Memmert, 2010) positively correlate with the magnitude of the home advantage and corresponding the influence on referee decisions.

In an experimental study, investigating the effects of crowd noise on refereeing decisions in football, it was found that referees - viewing the challenges with the crowds' noise - were more uncertain in their decision making and awarded significantly fewer fouls (15.5%) against the home team, compared with those referees evaluating the same game in silence (Nevill, Balmer & Williams, 2002). Other studies showed that the crowd size has a direct effect on the number of first yellow cards awarded to the away team in Cup final games (Downward & Jones, 2007), referees tend to issue red cards and award penalties significantly more often against the away team (Pollard & Armatas, 2017) and demonstrated the positive influence of training on referees' objectivity and decisions-making to overcome the effect of social pressure from the stands (Nevill, Webb & Watts, 2013). Before the COVID-19 pandemic forced to play matches behind closed doors there was a study conducted on ghost games and the effects on refereeing. Specifically, a study from football games - that were played without attendance following safety requirements after hooligan incidents in Sicily (Italy) - showed that, under normal circumstances, home teams are favored by officials' decisions during matches (Pettersson-Lidbom & Priks, 2010). The authors state that *"the home team is punished less harshly than the away team across all outcomes in games with spectators [while] punished more harshly than the away team across all outcomes in games without spectators."* (p.213). Further, regression analysis shows that the estimated bias effect is statistically significant for all outcomes regarding number of fouls, number of yellow cards and number of red cards. The authors conclude that their data *"strongly suggests that it is the referee that changes his behavior in games without spectators rather than the players."* (p.214).

Current findings on the effects of the COVID-19 pandemic on the home advantage effect indicate that the home advantage declines (Follert et al., 2020; Scoppa, 2021; Sors et al., 2020). CIES Football Observatory investigated 63 leagues worldwide and concluded that between April and August 2020 the overall home advantage (home win percentage) decreased in 41 of 63 leagues by -2.1% in total ("CIES. Football Observatory. What about the home advantage," 2020). Bryson et al. (2020) state that *"without a crowd, fewer cards were awarded to the away teams, reducing home advantage [and that] these results have implications for the influence of social pressure and crowds on the neutrality of decisions."* Other findings indicate that ghost games

might not only influence performance related aspects of football matches, but also have a direct effect on the (nonverbal) behavior of professional football players, staff and officials on pitch during games (Leitner & Richlan, 2021). There were 19.5% fewer documented emotional situations in ghost games than in “regular games”, meaning that players, staff and officials got less involved in behavior like “words fights” and “discussions” with each other. Additionally, results from the “Austrian Bundesliga” indicate that ghost games during the COVID-19 pandemic have an effect on home advantage, with fewer home-wins and more away-wins and draws in ghost games (Leitner & Richlan, 2021).

Based on these previous and current studies investigating the absence of crowds in professional sports events, we hypothesized that the COVID-19 related ghost games in European elite football would have significant effects on the officiating of referees. The present study is the first of its kind examining these effects closely on home advantage and missing supporters on a large natural scale, outside experimental laboratory settings. The study further provides novel insights regarding the crucial question of whether referees normally tend to advantage home teams or disadvantage away teams. We expected the ghost games to have a substantial effect on fouls committed, number of cards awarded and an impact on the reasons for booking (criticism, unfair sportsmanship, foul play). In addition, we analyzed these factors in relation to the course of the games because we hypothesized to find - due to poorer performance of the home teams - peaks in the awarding of yellow cards for fouls depending on the current score. From a sport psychological perspective, the analysis of these parameters is of utmost importance, because they reflect not only a potential bias in refereeing but are based on psychological effects stemming from (less) perceived social pressure from the stands. Therefore, our results also have significance for the study of social psychological processes built on conformity and the development of trainings and interventions for referees to decrease the decision bias created by the home crowd.

Methods

Sample. Based on the overall point value of UEFA’s country coefficient list (“UEFA. Länder-Koeffizienten”, 2020) we chose Europe’s Top 15 leagues and excluded countries, in which leagues were suspended after the COVID-19 outbreak. This is because nations beyond rank 15 play a minor role in international football competition due to limited regular starters and a higher number of qualification rounds (up to 5 rounds with first and second leg). This plays a significant role when it comes to qualification for “UEFA Europa League” and especially for the top tier “UEFA

Champions League” (“UEFA. UEFA Champions League preliminary round draw,” 2020). Additionally, we selected only leagues that were statistically documented in detail on “transfermarkt.de”, which is an open and reliable statistics platform and regularly used as a source and forum for football related scientific studies (e.g., Franck & Nüesch, 2012). We analyzed the leagues’ matches played after the respective restarts with no or significantly limited attendance (season 19/20) and compared the acquired data to the respective rounds (i.e., matchdays) of season 18/19, which were played with regular attendance.

“La Liga” (Spain), “Premier League” (England), “1. Bundesliga” (Germany), “Serie A” (Italy), “Premier Liga” (Russia), “Süper Lig” (Turkey), “tipico Bundesliga” (Austria) and “Fortuna Liga” (Czech Republic) were included into the data sample. “Liga NOS” (Portugal), “Premier Liga” (Ukraine) and “Superligaen” (Denmark) were excluded from the study due to missing data in match statistics documentation regarding specific yellow card bookings. “Ligue 1” (France), “Jupiler Pro League” (Belgium), “Eredivisie” (Netherlands) and the “Scottish Premiership” (Scotland) aborted their seasons.

This led to a total sample size of 1286 matches, with 645 matches played in season 18/19 (regular attendance) and 641 matches played in season 19/20 (no or strongly limited attendance). The reason for fewer ghost games played in season 19/20 than “regular games” in season 18/19 can be found in the Russian “Premier Liga”, where 4 games were cancelled due to COVID-19 cases (FK Orenburg vs. FK Krasnodar [Round 24], FK Orenburg vs. Ural Ekaterinburg [Round 25], FK Tambov vs. FK Sochi [Round 29] and Krylya Sovetov Samara vs. FK Sochi [Round 30]). As mentioned above, Russia was the only country to let an extremely limited number of supporters (10% of stadium capacity) attend football matches during the COVID-19 pandemic. Due to the significant discrepancy in crowd numbers between the two seasons we decided to include the Russian league into our analysis.

Data. The following information was collected from “transfermarkt.de” for each team and match played in the respective leagues: Result (win, loss, draw), points earned (0, 1, 3), goals scored, fouls committed, number of yellow, yellow-red and red cards awarded, reason for booking (criticism, unfair sportsmanship, foul play) and number of spectators.

Test statistics. Data was statistically analyzed on round-level, leading to 73 rounds per season ($N = 146$). Due to ordinal scale of the data, non-parametric methods, two-sided Mann-Whitney-*U*-tests for independent data and Wilcoxon signed-rank test for dependent data were used to

investigate potential differences. Effect sizes are reported in Pearson's r , calculated as follows:

$$r = \frac{z}{\sqrt{N}}$$

Results

Match results. Figure 1 illustrates the total numbers and difference of match results statistics of the respective rounds analyzed between season 2018/19 and 2019/20. Home teams lost 55 (-17.7%) more games, away teams won 53 (+29.8%) more games (and vice versa for away teams), leading to 2 (-1.3%) fewer draws between regular games of 18/19 and ghost games of 19/20. We observed significantly fewer home wins ($U = 1991$, $p = .007$, $r = .222$) and more home losses ($U = 1913$, $p = .003$, $r = .249$) between regular matches of season 18/19 and ghost games of season 19/20.

Figure 1. Absolute differences in match results statistics. Illustration shows the results of home and away teams in the highest football (soccer) leagues of Spain, England, Germany, Italy, Russia, Turkey, Austria and Czech Republic. Bar plots are based on aggregated match results statistics of rounds played in the leagues as ghost games (no or strongly limited attendance) in season 2019/20 and respective rounds of regular matches (regular attendance) in season 2018/19 ($N = 146$). Data shows that home teams won fewer

matches (-55) and away teams won more matches (+53) during the ghost games in season 2019/20. There was just a marginal difference in draws (-2). There is a significant difference between seasons for number of wins and losses of home teams (and vice versa for away teams).

Home advantage. Figure 2 illustrates the relative change in team performance when playing at home between seasons of 2018/19 (regular attendance) and 2019/20 (ghost games). To analyze the home advantage as the difference between home wins, home losses and draws within one season, results show that in the season 2018/19, home teams won 48.1%, lost 27.6% and drew in 24.3% of all analyzed games with regular attendance.

Figure 2. Relative changes of Home Advantage. Illustration shows home advantage between games with regular attendance (season 2018/19) and ghost games (season 2019/20) in the highest football leagues of Spain, England, Germany, Italy, Russia, Turkey, Austria and Czech Republic. Bar plots are based on aggregated match results statistics of rounds played in the leagues as ghost games (no or strongly limited attendance) in season 2019/20 and respective rounds of regular matches (regular attendance) in season 2018/19 ($N = 146$). Results show that home teams won significantly more often in matches with regular attendance (home advantage). In ghost games this effect vanished and the difference between the number of wins and losses is not significantly different.

This difference between the number of home wins compared to home losses is statistically significant. Therefore in the season 2018/19 with regular attendance, home teams won significantly more often (than they lost) in home games ($z = -5.376$, $p = .000$, $r = .445$). In contrast, in the season 2019/20, home teams won 39.8%, lost 36.0% and drew 24.2% of all analyzed ghost games. This difference between the number of home wins compared to home losses is not significant. Therefore, in the season 2019/20 with ghost games, home teams did not win significantly more often (than they lost) in home games ($z = -1.264$, $p = .206$, $r = .105$). It should be noted that we decided against excluding draws as in other studies on home advantage (e.g. Jamieson, 2010). If calculated without draws (i.e., taking into consideration only the games that resulted in a win or loss), the home advantage increases to 63.5% in season 2018/19 (which is in line with the findings of the meta-analysis by Jamieson, 2010) and 52.5% in season 2019/20.

Fouls and yellow cards. From a sport and social psychological perspective, the analysis of fouls and cards is even more interesting than the analysis of match results, because these parameters are more proximal to actually displayed (mis)behavior. Aggregation of all committed fouls from all analyzed matches of the 8 included leagues and comparison between the two seasons of 2018/19 (regular games) and 2019/20 (ghost games) shows that both home (+296 fouls / +3.7%) and away (+75 fouls / +0.9%) teams committed more fouls in ghost games. There is a significant increase in total fouls committed by home teams ($U = 2143$, $p = .041$, $r = .169$) and no significant difference in total fouls committed by away teams ($U = 2365$, $p = .240$, $r = .097$) between regular matches of season 18/19 and ghost games of season 19/20. In addition, in ghost games the total number of yellow cards awarded to the home teams increased (+148 yellow cards / +11.7%), whereas it decreased for the away teams (-77 yellow cards / -5.5%). There is no significant difference in the total yellow cards awarded to home teams ($U = 2170$, $p = .053$, $r = .160$) and the total yellow cards awarded to away teams ($U = 2409.5$, $p = .317$, $r = .083$) between regular matches of season 18/19 and ghost games of season 19/20.

Figure 3 illustrates the total numbers and difference of yellow cards awarded for criticism, unfair sportsmanship and foul play of the respective rounds analyzed between season 2018/19 and 2019/20. Comparing absolute and relative numbers of yellow cards awarded for criticism, unfair sportsmanship, and foul play for home and away teams between regular games of season 18/19 and ghost games of season 19/20 showed the following: yellow cards for criticism (home teams: +41 / away teams: +34) increased by 53.2% for home teams and by 36.6% for away teams. Unfair sportsmanship (home teams: -132 / away teams: -135) decreased by -57.6% for home teams and by -54.2% for away teams. Contrarily, yellow cards awarded for fouls increased

strongly for home teams (+238) by 26.2% but only slightly (+28) for away teams (+2.8%). We observed significantly more yellow cards awarded for criticism for the home teams ($U = 2057.5$, $p = .013$, $r = .205$) and for the away teams ($U = 2173$, $p = .048$, $r = .164$) between regular matches of season 18/19 and ghost games of season 19/20. Furthermore, there were significantly fewer yellow cards awarded for unfair sportsmanship for the home teams ($U = 1297$, $p = .000$, $r = .451$) and for the away teams ($U = 1513.5$, $p = .000$, $r = .380$) between regular matches of season 18/19 and ghost games of season 19/20. Finally, there was a significant difference in more yellow cards awarded for foul play for the home teams ($U = 1712.5$, $p = .000$, $r = .309$) and *no* significant difference in yellow cards awarded for foul play for the away teams ($U = 2497.5$, $p = .513$, $r = .054$) between regular matches of season 18/19 and ghost games of season 19/20.

Figure 3. Absolute differences in Criticism, Unfair Sportsmanship and Foul Play. Illustration shows yellow cards (criticism, unfair sportsmanship & foul play) awarded to home and away teams in the top football leagues of Spain, England, Germany, Italy, Russia, Turkey, Austria and Czech Republic. Bar plots are based on aggregated match results statistics of rounds played in the leagues as ghost games (no or strongly limited attendance) in season 2019/20 and respective rounds of regular matches (regular attendance) in season 2018/19 ($N = 146$). Data shows that both home (+41) and away (+34) teams earned more yellow cards for criticizing officials' decisions during the ghost games in season 2019/20. On the contrary, both home (-132) and away (-135) teams earned fewer yellow cards for unfair sportsmanship behavior. Number

of cards awarded for fouls strongly increased for home teams (+238) but only slightly for away teams (+28) in ghost games. There is a significant difference between seasons for the number of yellow cards awarded for criticism for both home and away teams, for unfair sportsmanship for both home and away teams and for committed fouls for home teams but *not* for away teams.

Due to the findings of significantly increased yellow cards awarded for fouls, we performed an in-depth analysis by collecting data on the relationship between course of play and the awarding of yellow cards. We found this effect to be independent of the current score when yellow cards were awarded, but dependent of the team (home – away). Figure 4 illustrates that, regarding yellow cards awarded for foul play, every condition (winning, losing, drawing) of the home team differs significantly in season 2019/20 from season 2018/19, while there is no significant effect for any condition of the away team.

Figure 4. Absolute differences in yellow cards for foul play depending on course of game. Absolute differences of yellow cards of home and away teams while winning, losing, or drawing in respective games of season 2018/19 (regular attendance) and season 2019/20 (limited attendance). Results indicate that home teams earn significantly more yellow cards for fouls while winning (+65), losing (+70) or drawing (+103)

in games without attendance in season 2019/20. In contrast, there is no such significant effect for away teams while winning (+61), losing (-11) or drawing (-22).

We observed significantly more yellow cards awarded for fouls for the home teams while leading ($U = 2060.5$, $p = .017$, $r = .197$), but not for the away team while leading ($U = 2195$, $p = .063$, $r = .154$) in ghost games of season 19/20. Furthermore, there is a significant difference in more yellow cards awarded for fouls for the home teams while trailing ($U = 2100$, $p = .026$, $r = .184$) but not for the away teams while trailing ($U = 2623.5$, $p = .872$, $r = .013$) in ghost games of season 19/20. Similarly, we observed significantly more yellow cards awarded for fouls in ghost games of season 19/20 for the home teams while the score was draw ($U = 2034$, $p = .013$, $r = .205$) but not for the away teams ($U = 2564.5$, $p = .694$, $r = .033$).

Discussion

The first main finding of our study is that overall, football (soccer) teams of Europe's elite leagues, lose significantly more of their home games and win significantly more of their away games, when there are no supporters in the stadium attending the matches. This means that these "ghost games" (no attendance) have a significant effect on the home advantage effect. This finding is supported by data of CIES Football Observatory, who also found an overall decrease in home win percentage in the same time window (from April 2020 to August 2020) by -2.1%. Specifically, CIES found major decrease of home advantage in Austria (-15%), Germany (-14.1%), Russia (-8.9%), Spain (-6.1%) but no change in Turkey (0%) and minor increase in Italy (+0.1%), England (+0.8%) and Czech Republic (+1.4%) ("CIES. Football Observatory. What about the home advantage," 2020). There are numerous studies showing that home teams generally win more games when competing at home and performing better when supported from the ranks (for a meta-analysis see e.g. Jamieson, 2010). Corresponding evidence was also identified in our study in the games with supporters taking place in the 2018/19 season, with a quantified home advantage of 63.5% home-win-rate or a plus of 0.61 points per game for home (1.69 points per game) relative to away (1.07 points per game) teams. Without supporters on matchday, the well documented effect of home advantage diminishes to 52.5% home-win-rate or a plus of only 0.11 points per game for home (1.44 points per game) relative to away (1.32 points per game) teams. Interestingly the number of draws appears to be stable and unaffected by ghost games. By and large, our findings are in line with other current studies on the COVID-19-related ghost games in

professional football (e.g., Bryson et al., 2021; Follert et al., 2020; Scoppa, 2021; Sors et al., 2020).

The second (behavior-related) main finding of our study is that home teams are awarded with significantly more yellow cards for committed fouls in ghost games than in “regular games” (with supporters present). In contrast, the number of yellow cards for fouls awarded to away teams is unaffected by ghost games. Conversely, other rule infringements awarded with yellow cards increase (criticism) or decrease (unfair sportsmanship) similarly for both home and away teams. The finding on significantly decreased yellow cards awarded for unfair sportsmanship are in line with results from recent research, where it was found that ghost games have an overall calming effect on players, staff and officials, with an increase in fair-play behavior (Leitner & Richlan, 2021). Regarding the significant increase in yellow cards awarded for criticism we argue that this represents another effect which was also found in the same study: referees tend to engage themselves significantly less during protest or words fight behavior with players. We argue that the increase in yellow cards for criticism reflects the referee's behavior to stop nascent discussions because they feel less obliged to justify their decisions to the players due to the lack of social pressure from the audience.

We further analyzed the course of the games and documented at what point in the matches yellow cards were awarded for fouls. Our initial assumption was that - due to the average worse performance of the home teams in season 19/20 - the increased number of yellow cards was due to bad performance, i.e., trailing in score. Our analyses, however, showed that this was not the case and that a significant increase in yellow cards awarded for fouls could be observed in *all* three score conditions (winning, losing, drawing).

We argue that due to missing supporters, referees act - based on the theories and findings of e.g. Nevill, Balmer & Williams (2002), Nevill, Webb & Watts (2013), Pettersson-Lidbom & Priks (2010) and Unkelbach & Memmert (2010) - more objectively in their decision making during ghost games, which leads to consequent booking of home teams after rule infringement. As concluded by Pettersson-Lidbom & Priks (2010) ghost games decrease the effect of “social pressure” from the stands and therefore lead to changes in refereeing and officials’ behavior. Our results further suggest that referees - when spectators are present - normally tend to advantage the home team. This is because our results show that during ghost games, only home teams are significantly more awarded with yellow cards for fouls and not away teams. Our findings and conclusions are consistent with the experimental study by Nevill, Balmer & Williams (2001), who found referees - watching a recorded football game - to significantly decide less fouls against the home team when the home crowd’s acoustic reactions were hearable in ambiguous and critical situations (such as

fouls) than when TV audio was turned off. In contrast, decisions against the away team were not significantly different in both conditions (noise vs. no noise from the home crowd).

Scientific literature shows that in controversial and ambiguous situations - especially the evaluation of tacklings in football are one of the most challenging decisions referees must fulfill consistently during a game - human beings tend to rely (unconsciously) on the opinion of the majority, in this case the crowd supporting the home team. Another potentially confounding factor is the narrow time window to make quick decisions in a game that has become faster and more intense in recent years. Referees find it increasingly difficult to correctly oversee and evaluate the increasingly fast-paced situations, as football in general has become more and more athletic and intense, also for tactical reasons. Intensive pressing schemes, which - instead of being played dynamically for rather short phases of the game in the past - are now part of the basic tactical orientation of many clubs. These developments have also favored the introduction of the so-called video assistant referee (VAR). Because due to the increased general dynamics of the game, many decisions - which potentially have a massive influence on the outcome of games - can no longer be made satisfactorily reliably without technical aids. However, the introduction of video evidence does not play a role for the present study because the VAR may only intervene in the following four basic situations when the initial decision by the referee is potentially wrong: 1) Goal 2) Penalty 3) Red card 4) Player mix-up (in awarding a yellow, yellow-red or red card). The incorrect awarding of a yellow card for a (supposed) foul is no reason for the VAR to intervene.

We argue that our finding of referees tending to advantage home teams in matches with supporters leads to novel approaches for developing efficient methods and interventions in the training of referees. It is conceivable that multistage procedures in such a training, comprising of the following central training contents, could lead to success to better protect against the influence of social pressure from the crowd: 1) Presentation of the scientific findings regarding social pressure on the experience and perception of referees 2) Raising awareness about the significant effect of social pressure on objective refereeing and the result of home team advancement 3) Development of Virtual Reality Trainings that enable a deeper and direct experience of refereeing, accompanied with individual feedback regarding the correctness of the decisions made in controversial situations.

Although we assume that the COVID-19 pandemic has most likely a general psychological impact on the everyday experience of people worldwide - originating from uncertainty and fear - it is highly unlikely the sole reason for changed on-pitch-behavior of protagonists in professional football. Rather, it is more probable that situational factors during competition have a more substantial impact on the experience of referees. Because the most important matchday-related

difference between regular matches in late stages of season 2018/19 and ghost games in late stages of season 2019/20 is the missing crowd and its external stimulation, we assume that our documented effects of decreased home advantage and increased yellow card booking for fouls for home teams mainly attribute to the missing supporters in the stadium.

Limitations. We cannot exclude the possibility that ghost games have a substantial impact on the "aggression potential" of players. Theoretical models and studies exist on the assumption that home advantage reflects an evolutionary behavior of territorial defense. In this context, studies show that players of home teams have higher testosterone levels than players of visiting teams (e.g. Neave & Wolfson, 2003). It is reasonable to assume that the missing of a home crowds' support creates a void in this territorial defense mechanics that must be compensated by some sort and changes the on-pitch behavior of the home team players. This effect could result in increased (dysfunctional) aggressive behavior, which, in turn, results in more fierce tackles and ultimately in more bookings for fouls. However, this hypothesis is contradictory to results from a recent study, which shows that about 20% fewer emotional situations can be observed between players, coaches, and referees due to the lack of an audience (Leitner & Richlan, 2021).

In contrast to other studies, we decided not to analyze the data on league level or include a vast number of different (worldwide) leagues. The reason is the deliberately focused scope of our study, concentrating on both economic and sporting top tier European leagues. As mentioned above, European top 15 leagues are the most important football leagues in the world, with regular attendance in major tournaments such as UEFA Champions League and UEFA Europa League. In our view it is not sensible to mix elite leagues and minor leagues (as second or even third leagues) when investigating complex sport psychological phenomena like home advantage and underlying mechanisms regarding the effects of (big) crowds on referee decisions. In our opinion, a more focused and controlled approach is more favorable from an empirical standpoint.

Additionally, we want to note that there are various possible approaches regarding the time frames for contrasting match data from different rounds of football played over different seasons in different countries. Because we believe that stretching the time horizon for analysis only creates inaccuracies, we decided to compare the ghost games of season 2019/20 only with games from the same rounds of the previous season of 2018/19. For example, the comparison of two consecutive seasons decreases biases such as evolution of tactics, rules, league phases, play level of teams and leagues. We are fully aware that there are other research groups dealing with this matter differently, but we strongly believe that our approach stands on reasonable empirical grounds, particularly considering the remarkably fast development of elite football.

Conclusions. We conclude that due to the missing supporters in games of professional elite football during the COVID-19 pandemic, referees perceived less social pressure from the home crowd, leading to the dissolvment of the home advantage effect. Referees act more objectively in their decision making regarding ambiguous situations such as the evaluation of tacklings, leading to a significant rise of yellow cards awarded for fouls only for home teams but *not* for away teams. This indicates that referees give an (unconscious) advantage the home teams in games with regular attendance - contributing to the effect of home advantage - while *not* disadvantaging the away team. Our findings go well in line with conclusions from previous research. This is, however, the first study to demonstrate the effects of social pressure on the decision making of referees on a large scale in a natural, not-experimental setting. Finally, our research results provide an empirical basis for the development of training methods to minimize the influence of the audience on referees' decision making in the future.

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References

- Agnew G.A., & Carron A.V. (1994). Crowd effects and the home advantage. *International Journal of Sport Psychology*, 25, 53-62.
- Allen M.S., & Jones M.V. (2014). The "Home Advantage" in Athletic Competitions. *Current Directions in Psychological Science*, 23(1), 48-53. <https://doi.org/10.1177/0963721413513267>.
- Arent S.M., & Landers D.M. (2003). Arousal, anxiety, and performance: A reexamination of the inverted-U hypothesis. *Research Quarterly for Exercise Sport*, 74(4), 436-444. <https://doi.org/10.1080/02701367.2003.10609113>.
- Bryson A., Dolton P., Reade J.J., Schreyer D., & Singleton C. (2020). Causal effects of an absent crowd on performances and refereeing decisions during Covid-19. *Economics Letters*, 198, Article 109664. <https://doi.org/10.1016/j.econlet.2020.109664>.

Cialdini R.B., & Goldstein N.J. (2004). Social Influence: Compliance and Conformity. *Annual Review of Psychology*, 55, 591-621. <https://doi.org/10.1146/annurev.psych.55.090902.142015>.

CIES. Football Observatory. (2020) What about the home advantage after the COVID-19 pandemic? Retrieved from <https://football-observatory.com/What-about-the-home-advantage-after-the-COVID-19-2470>. Accessed November 11, 2020

Courneya K.S., & Carron A.V. (1992). The home advantage in sport competitions: A literature review. *Journal of Sport and Exercise Psychology*, 14, 28–39. <https://doi.org/10.1080/02640410400021542>.

Downward P., & Jones M. (2007). Effects of crowd size on referee decisions: Analysis of the FA Cup. *Journal of Sports Sciences*, 25(14), 1541-1545. <https://doi.org/10.1080/02640410701275193>.

Follert F., Daumann F., & Passon L. (2020). Zur Bedeutung der Fans im professionellen Fußball im Lichte der COVID-19-Pandemie. *Sciamus – Sport und Management* 2, 28-49.

Franck E., & Nüesch S. (2012). Talent and/or popularity: What does it take to be a superstar? *Economic Inquiry* 50(1), 202-216. <https://doi.org/10.1111/j.1465-7295.2010.00360.x>.

Gould D., & Krane V. (1992). The arousal–athletic performance relationship: Current status and future directions. In T.S. Horn (Ed.), *Advances in sport psychology* (pp. 119-142). Human Kinetics Publishers.

Goumas C. (2012). Home advantage and referee bias in European football. *European Journal Sport of Science*, 14(1), 243-249. <https://doi.org/10.1080/17461391.2012.686062>.

Jamieson J.P. (2010). The Home Field Advantage in Athletics: A Meta-Analysis. *Journal of Applied Social Psychology* 40(7), 1819-1848. <https://doi.org/10.1111/j.1559-1816.2010.00641.x>.

- Leitner M.C., & Richlan F. (2021). Analysis System for Emotional Behavior in Football (ASEB-F): Matches of FC Red Bull Salzburg without Supporters during the COVID-19 Pandemic. *Humanities & Social Sciences Communications*, 8, Article 14. <https://doi.org/10.1057/s41599-020-00699-1>.
- Neave N., & Wolfson S. (2003). Testosterone, territoriality, and the “home advantage”. *Physiology & Behavior*, 78, 269-275. [https://doi.org/10.1016/s0031-9384\(02\)00969-1](https://doi.org/10.1016/s0031-9384(02)00969-1).
- Nevill A.M., Balmer N.J., & Williams A.M. (2002). The influence of crowd noise and experience upon refereeing decisions in football. *Psychology of Sport and Exercise*, 3, 261-272. <https://doi.org/doi:10.1016%2FS1469-0292%2801%2900033-4>.
- Nevill A.M., Newell S.M., & Gale S. (1996). Factors associated with home advantage in English and Scottish soccer matches. *Journal of Sports Sciences*, 14, 181-186. <https://doi.org/10.1080/02640419608727700>.
- Nevill A., Webb T., & Watts A. (2013). Improved training of football referees and the decline in home advantage post-WW2. *Psychology of Sport and Exercise*, 14, 220-227. <https://doi.org/10.1016/j.psychsport.2012.11.001>.
- ORF Sport. (2020). Frühlingserwachen in Europas Ligen. Retrieved from <https://sport.orf.at/stories/3062475/>. Accessed September 1, 2020
- Unkelbach C., & Memmert D. (2010). Crowd Noise as a Cue in Referee Decisions Contributes to the Home Advantage. *Journal of Sport and Exercise Psychology*, 32, 483-498. <https://doi.org/10.1123/jsep.32.4.483>.
- Pettersson-Lidbom P., & Priks M. (2010). Behavior under social pressure: Empty Italian stadiums and referee bias. *Economics Letters*, 108, 212-214. <https://doi.org/10.1016/j.econlet.2010.04.023>.
- Pollard R. (2008). Home advantage in football: A current review of an unsolvable puzzle. *Open Sports Sciences Journal*, 1, 12-14. <https://doi.org/10.2174/1875399X00801010012>.

Pollard R.P., & Armatas V. (2017). Factors affecting home advantage in football World Cup qualification. *International Journal of Performance Analysis in Sport*, 17, 121-135. <https://doi.org/10.1080/24748668.2017.1304031>.

Pollard R.P., Prieto J., & Gómez M.Á. (2017). Global differences in home advantage by country, sport and sex. *International Journal of Performance Analysis in Sport*, 17(4), 586-599. <https://doi.org/10.1080/24748668.2017.1372164>

Scoppa V. (2021). Social pressure in the stadiums: Do agents change behavior without crowd support?. *Journal of Economic Psychology*, 82, Article 102344. <https://doi.org/10.1016/j.joep.2020.102344>.

Sors F., Grassi M., Agostini T., & Murgia M. (2020). The sound of silence in association football: Home advantage and referee bias decrease in matches played without spectators. *European Journal of Sport Science*, 1-9. <https://doi.org/10.1080/17461391.2020.1845814>.

SPIEGEL Sport. (2020). So planen Europas Fußballligen den Neustart. Retrieved from <https://www.spiegel.de/sport/fussball-so-planen-europas-fussballligen-den-neustart-a-135cac8b-8571-4fe8-b6e1-75b364cbb896>. Accessed September 1, 2020

UEFA (2020) Länder-Koeffizienten. Retrieved from <https://de.uefa.com/memberassociations/uefarankings/country/#/yr/2020>. Accessed September 4, 2020

UEFA. (2020). UEFA Champions League preliminary round draw. Retrieved from <https://www.uefa.com/uefachampionsleague/draws>. Accessed December 15, 2020

Unkelbach C., & Memmert D. (2010). Crowd Noise as a Cue in Referee Decisions Contributes to the Home Advantage. *Journal of Sport and Exercise Psychology*, 32, 483-498. <https://doi.org/10.1123/jsep.32.4.483>