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Beyond the Roar: Unravelling Audience Influence on Football Performance

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Abstract

According to social facilitation theory the presence of others affects individuals' sporting performance. Although based on extensive research, the theory has been scarcely tested in real sporting environments. However, audience restrictions due to the COVID-19 pandemic offered rare opportunities to examine effects of spectators' presence and absence on football players' performances. To exploit these opportunities, we collected data on individual players' performances in the English Premier League (47,541 player performances in matches from the start of the 2017/18 season to 23rd January 2022) and Swedish Allsvenskan (25,249 performances in the 2018-2021 seasons). Results show that players' performances were significantly better in the presence than in the absence of an audience (and the effect of audience presence was moderated by playing home or away) in the Premier League, but not Allsvenskan. Conversely, the effect of audience presence was moderated by average attendance and average stadium filling in and the relative skill of the opponent in Allsvenskan, but not the Premier League. The differences in results could be at least partly due to contextual differences between the two leagues, particularly in the average quality of players (which is higher in the Premier League). The study extends understanding of the complex nature of social facilitation in football, and highlights needs for further rigorous investigation of the mechanisms underlying the detected effects.

Keywords: *Social Facilitation, Audience Effects, Choking, Football, COVID-19*

The numerous consequences of the COVID-19 pandemic included restrictions on audiences for professional sporting events. One issue frequently discussed by various expert commentators in media was whether players' performances in full stadia differed from those in front of empty stands. Although there seemed to be a consensus that an audience influences individuals' performance, the strength of the effect (if any) in football has not been previously analyzed, to our knowledge, using behavior-based (i.e. event data on the pitch) individual-level performance measures. The COVID-19 constraints provided rare opportunities to assess audiences' effects on individual football players' performance without artificial interventions by researchers. Thus, the aim of this study was to exploit these opportunities, using the expected goals method to assess individual performance outcomes (Brechot & Flepp, 2020; Rathke, 2017).

The mentioned consensus is rooted in a key element of social facilitation theory: the assumption that the presence of others influences people's cognitive and physiological performance. Previous research has confirmed that the presence of others can influence performance, and that the effects may be either positive or negative (Manstead & Semin, 1980; Zajonc, 1965). Various explanatory models have been proposed, which can be divided into two categories based on their putative mechanism of action (Strauss, 2002). According to arousal theories, arousal increases individuals' inclination to use their dominant responses (Zajonc, 1965), which are likely to be appropriate and facilitate the performance of well-practiced tasks. However, for tasks that are unfamiliar and/or have not been well practiced, the dominant responses are likely to be inappropriate, and impair performance (Zajonc, 1965). In contrast, according to attention-based theories the presence of others (an audience) can impair individuals' performance of cognitively demanding or complex tasks because it diverts some of the individuals' attention (Manstead & Semin, 1980).

Another factor thought to affect social facilitation is the individuals' skill level. Some studies have found that skilled players tend to perform better in the presence of an audience, while less skilled players perform more poorly. This has been found in contexts when players are ranging

within an elite context (Dube & Tatz, 1991; Jane, 2022). However, other studies have found no effect of skill level (Forgas, Brennan, Howe, Kane, & Sweet, 1980), or even that highly skilled participants perform less well in the presence of spectators (Paulus & Cornelius, 1974).

A few studies have also examined effects of audience size on performance, with varying results (Böheim, Grübl, & Lackner, 2019; Jane, 2022). For example, Russell (1983) found that in ice hockey, larger audiences were associated with less aggressive and poorer performance of away teams, while increases in audience density were associated with decreases in performance of both home and away teams. Similarly, Böheim et al. (2019) found that in basketball increases in audience size negatively affected the free-throw accuracy of home teams, but not away teams.

Audiences are thought to influence players' performance through noise or cheering (Inan, 2020), and important factors reportedly include the audience's size, density, intensity, and proximity (Pollard & Gómez, 2014). These factors can influence home advantage by affecting home and away teams, and possibly referees, in several ways. One is that large audiences are generally expected to positively influence the home team's performance (Inan, 2020). However, audience effects can both improve and impair performance. A sympathetic audience may significantly increase the home team's probability of winning, but an unsympathetic audience may have negative effects on the home team (Boudreaux, Sanders, & Walia, 2017; Butler & Baumeister, 1998; Wallace, Baumeister, & Vohs, 2005).

Athletes' motivation is shaped by perceived success probability and the value of success—factors influenced by opponent strength and audience presence (Atkinson, 1964). A strong opponent may lower success expectancy but increase incentive value, especially for achievement-oriented athletes (Roberts, 1984). Audience presence can heighten public evaluation and pressure, amplifying these effects (Baumeister, 1984; Uziel, 2007). For example, a player on a top team facing a weaker opponent may stay focused with a crowd present but underperform without spectators due to reduced arousal or perceived importance. Performance in sport is methodologically challenging to capture, and changes in tactics, formations, skill level of opponents, strategies as well as psychological aspects. Match results, for example, contain about 50 percent randomness (Wunderlich et al., 2021). Therefore, judging individual performance by measures like goals, assists, tackles risk to contain bias as well as overestimate or underestimate players actual performance (Brechot & Flepp, 2020; Cefis & Carpita, 2021). In recent years, the ability to measure performance within games and over time has developed enormously. Depending on focus these measures apply on both team and individual levels. Performance is now based on probabilities of creating and preventing chances (Brechot & Flepp, 2020; Cefis & Carpita, 2021). Including the performance of individual players in matches would provide relevant performance measures for studies that aim to capture performance over time (Brechot & Flepp, 2020).

COVID -19 as a quasi-natural experiment

The outbreak of COVID-19 led to many professional sports being played without an audience, opening new possibilities to study social facilitation. Blomqvist Mickelsson and Shaw (2020) found that Mixed Martial Arts competitors who won their fights without an audience performed less well when an audience was present. Heinrich, Müller, Stoll, and Cañal-Bruland (2021) reported that the performances of male biathlon competitors were consistent with paradigmatic expectations for simple and complex tasks, as they skied faster, but shot with less accuracy in the presence of audiences than in their absence. Interestingly, however, women skied slower but shot more rapidly and accurately in the presence of audiences. Further interesting findings concerned darts players' performances, which were best in tournaments played with no audience, poorer with artificial crowd noise, and poorest with an audience (Greve, van Meurs, & Strauss, 2023). A complexity noted in football matches was that home players missed more penalty kicks, but away players scored more, in the presence of an audience (Massimiliano Ferraresi & Gucciardi, 2021). In contrast, Fazackerley, Gorman, Minett, Caia, and Kelly (2022) detected no systematic differences in more than 20 offensive, defensive and GPS metrics of rugby matches with and without audience and concluded that and audience probably did not significantly affect rugby players' performance.

However, most relevant studies have examined the influence of audiences on football matches on team level. Many authors have found, as expected, that home advantage is weaker in matches without audiences than in matches with audiences (Delbianco, Fioravanti, & Tohmé, 2023; Massimiliano Ferraresi & Gucciardi, 2023; Hill & Van Yperen, 2021; Jiménez Sánchez, Lavín, & Endara, 2021; Reade, Schreyer, & Singleton, 2020). An analysis of home advantage using expected goals (i.e., estimated probabilities of goals being scored from created chances) detected the same trend (Cross & Uhrig, 2020). This decrease has often been attributed to changes in referees' decision-making as well as audiences' impact on performance (Leitner, Daumann, Follert, & Richlan, 2023).

To our knowledge, no study have used an individual level in invasion team sports trying to grasp a combined total measure of performance within a full game and not accuracy or completion measures of a set pieces of the game (Massimiliano Ferraresi & Gucciardi, 2021) or sets of multiple performance measures based on GPS data in rugby and therefore not capturing the probabilistic measurements of performance in relation to the offensive and/or defensive performance of individuals within a team (Fazackerley, Gorman, Minett, Caia, & Kelly 2022).

The current study

Despite this, no previous research has examined the effects of spectators' absence or presence on individual players' performance in team sports, despite calls for such research, e.g., from Reade et al. (2020). Therefore, the aim of this study was to investigate potential differences in players' performance in front of an audience and in empty stadiums.

Research into social facilitation has shown that the presence of others affects performance through complex processes. It may have positive effects in some cases, but negative effects in others, e.g., it may promote 'choking', the failure to perform as well as expected (Bond & Titus, 1983; Böheim, et al., 2019; Jane, 2022; Reade et al., 2020; Russell, 1983; Uzeil, 2007) The effects, positive or negative, are thought to depend on complex interactions between both individual and contextual factors. Here we address some of this complexity by examining effects of potential moderating factors. A common statement by studio experts was that younger players benefit from playing in empty stadia, while older players need crowd pressure to perform. Furthermore, both the size and density of the audience have suggested importance as contextual factors for the social facilitation effect (Böheim, et al., 2019; Jane, 2022; Russell, 1983). Thus, we included players' age, audience size and audience density as

moderating variables. Based on the decline in home advantage associated with the absence of spectators described by Reade et al. (2020), we also wanted to investigate potential moderating effects of playing home and away. Finally, individual ability level has claimed importance for social facilitation (Dube & Tatz, 1991; Jane, 2022), and intuitively the ability of players' teams could also be influential, so it was added as a final moderating variable. In summary, a secondary objective was to investigate whether potential audience effects are moderated by the following factors: players' age, crowd size, stadium fill percentage, playing home or away, and the overall strength of a player's team.

Methods

Sample

Performance statistics for individual Premier League (England) and Allsvenskan (Sweden) players were obtained with permission from Twelve Analytics (2022). These statistics covered the performance of all players in every Premier League match from the start of the 2017/2018 season to 23 January 2022, and all Allsvenskan players in all matches for the complete 2018 to 2021 seasons. They included data on 47,541 performances of individual players representing 26 teams in 1,734 Premier League games (34,433 in front of an audience, 12,230 without an audience, and 878 with a limited audience). The Allsvenskan dataset covered 25,249 appearances by individual players of 23 teams in 960 matches (18,374 in front of an audience and 6,875 without an audience). Data from both leagues included measures of each player's performance, their position in each game and whether they played for the home or away team. The analyses did not include performances in which a player played less than 15 minutes.

Measures

Descriptive statistics for all variables used can be found in Table 1.

Performance data were derived from detailed statistics that reflect each player's contribution in each game. Rather than solely focusing on goals, assists, defensive tackles, the methodology is based on the recent advancements in sports analytics, assigns weight to diverse actions performed on the pitch. This approach aims to provide a more comprehensive assessment of a player's overall game impact (Brechot & Flepp, 2020).

The calculation of performance metrics is based on the concepts of expected goals (xG) and expected threat (xT). Expected goals quantify the likelihood of a shot being scored, considering factors such as shot location and angle. Expected threat, on the other hand, measures the potential of a team to score from a given position on the field, reflecting the value of ball movement and field positioning in creating scoring opportunities (Decreoos & Davis, 2020; Sumpter, 2021a; Karlsson, 2020).

The scoring system, developed by Twelve football, employs a sophisticated algorithm that analyzes hundreds of thousands of game events. This algorithm assigns a score to every player action ranging from -1000 to +1000. The scoring is structured around four primary action categories:

Defending: Actions that prevent the opposition from advancing or scoring, such as tackles and interceptions. This category corresponds to reducing the opponent's expected goals (xGA). Defending is further detailed by actions that either directly block scoring opportunities (e.g., shot blocks) or disrupt the build-up phase by intercepting passes, thereby diminishing the opposition's attacking momentum (Karlsson, 2020; Sumpter, 2021b).

Attacking: Movements that progress the play towards the opponent's goal. This is measured through expected threat (xT) values. Attacking actions encompass not only the direct passes or dribbles into dangerous areas but also include off-the-ball movements that reposition teammates and create space, ultimately enhancing the overall threat (Karlsson, 2020; Sumpter, 2021b).

Shooting: Attempts to score a goal, evaluated through expected goals (xG). In this category, each shot is quantified based on factors like distance, angle, and defensive pressure, which collectively determine its xG value. This measure reflects a player's effectiveness in converting chances into goal-scoring opportunities (Karlsson, 2020; Sumpter, 2021b).

Pressing: Efforts to regain ball possession by applying pressure on the ball carrier. Pressing actions are critical for disrupting the opposition's play, forcing errors, and triggering turnovers. They are quantified based on their effectiveness in limiting opponent actions and facilitating a rapid transition from defense to attack (Karlsson, 2020; Sumpter, 2021b).

Specifically, actions that increase a team's scoring probability by 10% are awarded 100 points under the attacking category. Conversely, actions that similarly increase the opponent's scoring probability result in a deduction of 100 points from the defending category (Sumpter, 2021; Karlsson, 2020).

The performance scores from these categories are then aggregated to formulate a continuous outcome variable representing each player's total performance. This variable is averaged per minute of play and standardized using z-scores to facilitate comparison across different games and players.

This methodological framework allows for a nuanced analysis of player performance, emphasizing the strategic elements of play that are not captured by traditional metrics such as goals and assists alone (Sumpter, 2021; Karlsson, 2020).

Since our main objective was to analyze players´ performance in the presence and absence of an audience, we generally excluded matches in which only a limited number of spectators was allowed. However, during a period in 2021 so few spectators were allowed (at most eight) for Allsvenskan matches that we coded them as matches without spectators. In July 2021, the maximum number of spectators was increased to 3000 per stadium section. During the following period spectator numbers varied greatly from match to match depending on whether the home team could bring spectators. Matches played with these restrictions sometimes had more spectators than matches played without restrictions. Therefore, Allsvenskan matches played under these more liberal restrictions were coded as matches with spectators.

Audience size/density statistics were obtained from the Transfermarkt website (Transfermakt, 2022), which provides attendance data for all Premier League and Allsvenskan games. The average attendance per match and percentage of the audience in the arena was used. Only matches with no attendance size or restrictions were considered. For teams that did not play in Premier League or Allsvenskan every year (due to relegation), the average attendance at home games was only considered when they played in the Premier League or Allsvenskan.

Players' ages were obtained by subtracting the year each match was played from each player's birth year, acquired from the cited website (Transfermakt, 2022).

Overall team quality and relative opponent quality was measured in terms of 'Soccer power index' (SPI) values, obtained from FiveThirtyEight (2022), which provide ratings of international football teams' overall strength where a higher value indicates a better team. Before each season, a team's SPI rating is based on the team's market value calculated by Transfermarkt and its rating at the end of the previous season. FiveThirtyEight has found that a team's market value relative to the league average correlates strongly with its SPI rating at the end of the season. After the beginning of a season, each team's SPI rating is adjusted after each game, based on the team's performance in the last match and the opponent's strength. The rating of each performance is based on the concept of expected goals (FiveThirtyEight, 2022). For team strength the players teams SPI at a the specified game was used. For relative opponent quality the players teams SPI was subtracted from the opponent teams SPI. A positive value indicated that the players team was higher ranked and a negative score meant that the opponent team to the individual players team was higher ranked.

Table 1: Descriptive statistics

	Premier League				Allsvenskan			
	Av. Att.	Av. Fill.	Age	SPI	Av. Att.	Av. Fill.	Age	SPI
N	43,683	43,683	43,683	43,683	23,429	23,429	23,429	22,669
Missing	0	0	0	0	0	0	0	760[a]
Mean	38,947	.97	26.7	71.5	8,892	.51	26.4	33.3
Median	31,952	.97	27	70.3	5,432	.48	26	32.2
SD	17,408	.06	3.83	11.4	6,833	.15	4.68	12.3
Minimum	10,213	.89	15	44.4	1,059	.11	16	9.95
Maximum	73,563	.99	40	95.8	23,899	.80	42	64.1

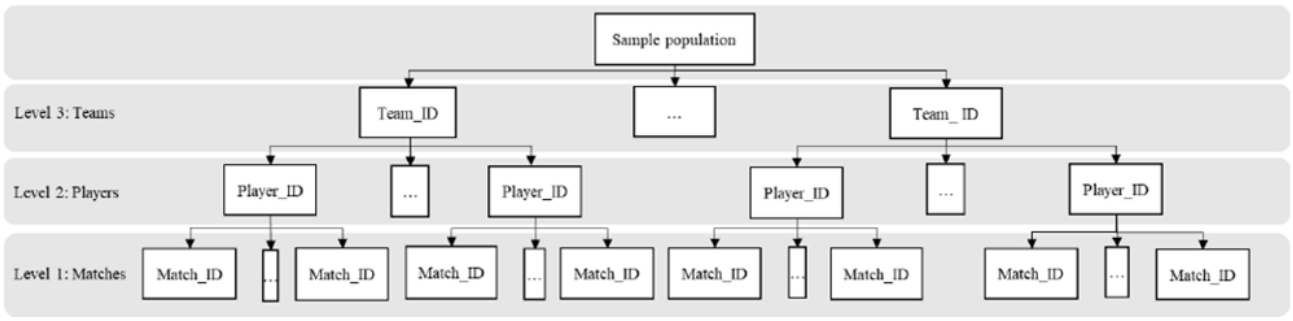
Note. Av. Att., Average home attendance; Av. Fill., Average home stadium filling; SPI, Team strength (SPI-ratings); SD, Standard deviation. [a] Missing because no SPI ratings were available for AFC Eskilstuna during the 2019 season.

Data analysis

The data were analyzed using two-level mixed linear models implemented in Jamovi 2.2.5 software. We examined the proportions of total variability attributable to each level to address potential dependencies in the dataset and thus minimize the risk of type 1 errors (Aarts, Verhage, Veenvliet, Dolan, & Van Der Sluis, 2014). We used intraclass correlations (ICC) to estimate dependency between scores and determine whether a multilevel approach was needed. Low ICC values indicate that a simpler model is preferable to one with higher levels (Nakagawa, Johnson, & Schielzeth, 2017).

We created a model with no independent variables to test the need for a three-level multilevel model, with player performances nested into players and players into teams (Figure 1). A cut-off point of ICC =.05 was used to estimate whether higher levels were required (Snijders & Bosker, 2012). ICC values indicating the proportions of total variability in performance to level 3 (teams) in the Premier League and Allsvenskan were .04 and .01, respectively, suggesting that three-level modeling was not necessary. The ICC values indicating the proportions attributable to level 2 (players) were .12 and .11, respectively, suggesting that two-level modeling was appropriate.

Figure 1: Flowchart nesting structures in the data set



As substantial proportions of the overall variability in player performance were attributable to level 2 (players) it was necessary to handle nesting effects, which commonly occur in repeated measure data structures. We used two-level mixed linear models to meet this need (Gueorguieva & Krystal, 2004; Ugrinowitsch, Fellingham, & Ricard, 2004).

The focal relationships involved multiple variables and the flexibility of mixed models allowed us to include variables of interest as well as possible confounding variables. All models were fitted using the Restricted Maximum Likelihood (REML) criterion, which reportedly results in less biased estimations than other possible criteria (Luke, 2017). To further investigate the models' fit, we used the Akaike Information Criterion (AIC), which indicates the best-fitting model for complex data structures (Park, Cardwell, & Yu, 2020). Steps to minimize the AIC included standardization of the outcome variable to total performance points per minute.In terms of random effects structures, we allowed intercepts to vary between players, and the relationship between audience presence and total points per minute to vary across players (thereby permitting random slopes and random intercepts, respectively) in all models. We also allowed the random coefficients to correlate. This random structure allowed us to capture differences between players while limiting the models' complexity.

As expected with the large dataset, the models' showed heteroskedasticity and non-normally distributed residuals. However, even substantially skewed and heteroscedastic distributions result in little overall bias in linear mixed models (Schielzeth et al., 2020). We performed robustness analysis by comparing the inference of the models to three alternative approaches: Yeo-Johnsson transformation of the independent variable to reduce non-normality (Yeo & Johnsson, 2000), heteroskedasticity-robust standard errors (Pustejovsky and Tipton, 2017), and bootstrap to relax the assumptions (Davison & Hinkley, 1997). The robustness analysis revealed no discrepancies in statistical inference between the methods

Confounding variables

Player position was included in all models as we regarded it as a potential confounding variable. We also thought that playing home or away could affect players' performance, so elucidating its relationship with performance was one of our research aims. However, we also recognized that it could be a confounding variable. Therefore, some of the models (described in more detail below) included an interaction term between home or away match and spectator attendance to test the possibility that playing at home or away influenced the effect of audience presence on player performance. The home/away variable was included in any other models to avoid possible confounding effects.

Models

A null model was created with no independent variables to establish a baseline for comparisons with more complex models. Model 1 was then created to examine the effect of audience presence on player performance (relative to playing without an audience). In this model the variable of most interest (playing with and without spectators) and the two identified potentially confounding variables (playing at home or away and player position) were clustered within the player variable.

A second model (Model 2) included the same variables as Model 1, but also an *audience presence * playing home/away* interaction term.

We created additional models to analyze the moderators' influences on potential effects of playing with or without an audience (Models 3-6). These models included the same variables as Model 1, except that each one included an additional variable. To avoid collinearity problems, one variable was added as a covariate at a time. We then tested the results before removing the variable. This procedure was repeated for the variables average home game attendance (Model 3), average stadium fill percentage (Model 4), player age (Model 5) and team SPI rating (Model 6).

Evidence from simulation studies suggests that, within a two-level model, the attainment of sufficient statistical power is achievable when sample sizes exceed 500 individuals at level 2 (Bell, et al., 2008).

Post-hoc analysis

Holm's sequential procedure was applied following all analyses including categorical variables. This is less conservative, but corrects type 1 errors just as effectively and has higher statistical power, than traditional Bonferroni correction (Eichstaedt, Kovatch, & Maroof, 2013). In the following sections significance refers to $P < 0.05$.

Statistical Power

Based on the guidelines provided by Raudenbush and Liu (2001) and considering our intra-class correlation coefficients (ICCs), the size at level 2 (players), and the number of observations per player (matches played), we infer that our sample size is sufficient. With an alpha level of 0.05 and aiming for 80% power, our dataset is robust enough to detect small to medium effect sizes. This assessment reassures us that the sample size not only mitigates potential bias due to random variance but also strengthens the generalizability of the results across similar sports performance datasets.

Results

Premier League

Full results regarding the explanation of variation in players' performance in the Premier League by our models are presented in Supplementary Table A and full fixed effects in Supplementary Table B. Results for interaction and moderating effects are shown in Table 2. Marginal and Conditional R^2 values indicate that fixed effects and the overall models explained 4—8 and 13—15 percent of the variance in total points per minute, respectively.

Results regarding fixed effects show that players generally performed better when an audience was present than without an audience. Player position and playing home/away were both significant predictors of player performance. Furthermore, one statistically significant audience *presence * playing home/away,* interaction effect was detected, indicating that presence of an audience was associated with a home field advantage for player performances, but as the stands emptied, this advantage disappeared. No other interaction effects was statistically significant.

Table 2: Fixed effect parameter estimates of two level mixed linear model in Premier League

	b (range)	SE (range)	*t* (range)	[95% CI] Min	[95% CI] Max	*p*
Main effects						
Intercept	-.23 to -.20	.01–.02	-15.73 to -14.99	.26	-.17	<.001
Audience presence (No-Yes)	-.10 to -.07	.01	-7.73 to -5.29	-.13	-.04	<.001
Home/Away (H-A)	.09–.11	.01	8.59–12.36	.07	.12	<.001
Position (Forward-Defender)	-.02 to .02	.02	-.62 to .75	-.06	.06	.453–.992
Position (Goalkeeper-Defender)	-.64 to -.63	.04–.05	-15.11 to -12.89	-.74	-.54	<.001
Position (Midfielder-Defender)	.09 to .12	.02	4.46 to 12.24	.05	.15	<.001
Average attendance	.09	.01	9.13	.07	.11	<.001
Average filling	.01	.01	.52	-.01	.02	.604
Age	.00	.01	.03	-.02	.02	.980
Team strength	.12	.01	12.59	.1	.13	<.001
Relative opponent strength	.19	.01	29.64	.18	.21	<.001
Interaction effects						
Audience ‘ home/away	-.09	.02	-4.57	-.13	-.05	<.001
Audience ‘ Attendance	.02	.01	1.30	-.01	.05	.193
Audience ‘ Filling	.01	.01	.31	-.02	.03	.757
Audience ‘ Age	.01	.01	1.10	-.01	.04	.270
Audience ‘ Team strength	.01	.01	1.19	-01	.04	.234
Audience presence (No-Yes) * Opponent strength	.02	.01	1.89	-.00	.05	.059

Note. H=Home; A=Away; SPI; SE: Standard Error; CI: Confidence interval.

Table 3: Fixed effect parameter estimates of two level mixed linear model in Allsvenskan

	b (range)	SE (range)	*t* (range)	[95% CI] Min	[95% CI] Max	*p*
Main effects						
Intercept	-.19 to -.17	.0.1 - .02	-11.91 to -11.29	-.22	-.16	<.001
Audience presence (No-Yes)	-.03 to -.01	.01 - .03	-1.78 to -.58	-.07	.04	.076-.564
Home/Away (H-A)	.14 - .15	.01	10.52 - 11.90	.12	.17	<.001
Position (Forward-Defender)	-.17 to -.15	.03	-6.19 to -5.82	-.22	-.10	<.001
Position (Goalkeeper-Defender)	.73 to -.72	.05	-15.39 to -14.56	-.83	-.63	<.001
Position (Midfielder-Defender)	-.01 to .02	.02	.49 to .83	-.05	.06	.410 - .628
Average attendance	.06	.01	4.71	.03	.08	<.001
Average filling	.04	.01	3.58	.02	.07	<.001
Age	.01	.00	.03	.00	.03	.008
Team strength	.07	.01	6.30	.05	.09	<.001
Relative opponent strength	.14	.01	14.86	.12	.16	<.001
Interaction effects						
Audience ‘ home/away	.00	.03	.04	-.05	.06	<.966
Audience ‘ Attendance	-.07	.02	-4.25	-.11	-.04	<.001
Audience ‘ Filling	-.04	.02	-2.06	-.08	.00	.040
Audience ‘ Age	-.01	.00	-1.49	-.01	.00	.137
Audience ‘ Team strength	.01	.02	.48	-.03	.04	.632
Audience presence (No-Yes) * Opponent strength	-.07	.01	-.4.54	-.11	.04	<.001

Note. H=Home; A=Away; SPI; SE: Standard Error; CI: Confidence interval.

Of the variables that were separately included, in Models 3-7, average attendance, team strength (SPI) and relative opponent strength had statistically significant main effects indicating that players performed better in front of larger crowds, players in better teams perform better and players perform better when their team is better ranked than the opponent. Average stadium-filling or players’ age did not. However, the findings of most interest from these models were that none of these variables had significant interactive effects with presence of an audience

Allsvenskan

Full results regarding the explanation of variation in players’ performance in Allsvenskan by our models are presented in Supplementary Table C and full fixed effects in Supplementary Table D. A summary of direct effects and all interaction and moderating effects are shown in Table 3. Marginal and Conditional R^2 values indicate that fixed effects and the overall models explained 4—7 and 13—15 percent of the variance in total points per minute, respectively.

Regarding the fixed effects, the results show that players did not perform better when an audience was present than without an audience. Player position and playing home/away were both significant predictors of player performance. Furthermore, significant main effects between playing home and away was detected, but no significant *audience presence * playing home/away* interaction effect (Model 2). All of the variables—average home attendance, average stadium filling, player age and team strength (SPI)—that were included separately, in Models 3-6, had significant main effects (Table 3). However, the results of most interest in these models were each variable’s possible interaction effect with the audience

presence where none showed any statistically significant interaction effects with the having an audience presence.

However, the findings of most interest from these models concerned the variables' possible interaction effects with an audience present. As shown in Table 3, the h*ome game average attendance* * *attendance presence* interaction resulted in a statistically significant positive relationship between players' performance and their teams' home game attendances when they were playing in front of an audience, but not when there was no audience.

Similar results were found for the *stadium filling* * *audience presence* interaction (Table 3 and Figure 2), as there was a significant positive relationship between players' performance and their teams' stadium-filling percentages when playing in front of an audience, but not in the absence of an audience.

Lastly, there was a negative statistically significant interaction effect between *relative opponent strength* * *audience presence* showing that players performed relatively worse against stronger opponents when an audience was present compared to when no audience was present.

To summarize, our results differed between the leagues. In the Premier League, but not Allsvenskan, the results showed that players' performances were significantly better in the presence of an audience than without an audience. Further, in the Premier League (but not Allsvenskan) the effect of audience presence could be moderated by playing home or away. Conversely, the results showed that the effect of audience presence was negatively moderated by average attendance, average stadium filling and the relative strength of the opposing team in Allsvenskan, but not the Premier League.

Discussion

Our analyses of effects of playing in the presence and absence of spectators on football players' performance, and potential moderating variables, indicate that audience presence affects performance to an extent even if the effects are small and individual differences are large. This is consistent with findings of previous research (Bond & Titus, 1983; Zajonc, 1965). However, our results also adds to the current knowledge about social facilitation in elite sport showing that the theory of social facilitation do have complex nuances and moderators that need to be more thoroughly investigated both experimentally with good control of confounds and in observational designs like ours with high ecological validity. Gaining better understanding on what statistically significant effects means for performance needs to be further investigated. These nuances were shown in the variation of relationships in the Premier League and Allsvenskan. In the Premier League, but not Allsvenskan, player performance was affected by audience presence alone. Furthermore, home advantage disappeared without an audience in the Premier League but not in Allsvenskan. However, in Allsvenskan, players performed better without an audience when their teams in general had smaller home attendances, lower stadium-filling percentages, or when facing stronger opponents. These results add further nuances to current understanding of the complex interactions involved in social facilitation.

The effects we detected were statistically significant (at the $P < 0.05$ level) and revealed interesting aspects of social facilitation, but they were small, which is also in line with previous findings (Bond & Titus, 1983). The 14 different models, seven for each league, explained between 4-8 percent of variance in Premier league and 4-5 percent in Allsvenskan. How to interpret models that explain between 4-5 percent of the variance and how that should be interpreted in a football context is a challenge. On one hand there are several aspects that explain how players perform in football games. On the other hand, even small changes in performance can have large impact in elite sport and therefore even small effects can have an actual impact on a team's overall performance in a game. For example playing home or away as in Premier League or for players in smaller teams in Allsvenskan. The effects' weakness can be partly explained by the complexity and high variability of the relations (positive and negative) between social facilitation and performance. Moreover, previous estimates of this kind are based on experimental research. A naturalistic setting, such as ours, does not allow such isolation of variables, so possible effects were likely to be even smaller than those previously observed. Furthermore, the presence or absence of an audience is just one of numerous factors that affect football performance and the statistical effects that can be seen may indicate that some are affected by playing in front of an audience than others.

There are five key findings of this study, all indicating that the considered variables seemed to have conflicting effects on the performance of players in the Premier League and Allsvenskan. However, we believe that the results can be explained by differences between the leagues in individual and contextual factors.

First, player performance was apparently facilitated by the presence of an audience in the Premier League, but not Allsvenskan. This can be explained by observations that the presence of others can enhance highly skilled individuals' performance but impair the performance of less skilled individuals (Dube & Tatz, 1991; Jane, 2022). Further, choking is more likely to occur when a task requires skill than when it requires effort (Wallace et al., 2005). Although both are professional leagues and skill level between groups will overlap to some degree, the average player in the Premier League (ranked as Europe's best league) is likely to be substantially more skilled than the average player in Allsvenskan (ranked as Europe's 23rd best league). Thus, Premier League players may have automated the processes associated with footballing tasks more fully than Allsvenskan, players, so higher percentages may be able to exploit the potential benefits of an audience. Similar pattern has been seen when comparing star players vs non star players in the highest baseball elite (i.e. Major League Baseball) as well (Jane, 2022).

The difference between leagues in the detected effect may also be influenced by differences in audience sizes and densities. The average attendance during the selected period in matches without restricted audience was 39,179 in the Premier League and 8,892 in Allsvenskan, with the stadiums being on average 96% and 51% full, respectively. A larger audience and fuller stadium are likely to create sharper contrasts between playing with and without an audience, potentially resulting in stronger social facilitation effects. However, varying results have been obtained in previous studies on the influence of crowd size and audience density on social facilitation effects. For example, Russel (1983) and Böheim et al. (2019) found that performances declined as audience sizes increased.

Our second key finding may add nuances to the first. In the Premier League, but not Allsvenskan, the performances of home team players, but not those playing away, were poorer without an audience than when an audience was present. Previous research has found that the presence of a large crowd positively affects home teams' motivation and performance (Boudreaux, et al., 2017; Inan, 2020). Furthermore, crowd size and density have claimed importance for home team advantage (Pollard &

Gómez, 2014). Our study's results are consistent with these reports, as they indicate that a bigger audience and fuller stadium do not necessarily improve performances of all players but might enhance home team performance.

The third key finding is that the average attendance had no apparent effect in the Premier League, but in Allsvenskan it had a significant effect. Players of Allsvenskan teams with above-mean average attendances performed significantly better than players in teams with average attendances below the mean, in the presence of spectators, but not in their absence. Differences in crowd sizes between the two leagues might be important here, as attendances for the Premier League matches ranged from 10,213 to 73,563 (CV = 45%) , compared to 1,059 to 23,429 (CV = 61%) in Allsvenskan showing that Allsvenskan differs more but on a lower level. Thus, players in Allsvenskan teams with normally large home crowds (relative to the Allsvenskan mean) may benefit from their habit of playing in front of a large home audience, when spectators are present, and this advantage may disappear when the audience disappears. On the other hand, Premier League teams are more similar in terms of audience size, and even the smallest home audience in the Premier League is large compared to Allsvenskan audiences. This may explain why average audience size does not have the same impact in the Premier League as in Allsvenskan. Hence, players who are used to large home audiences may be more prone to negative effects of the stands emptying than those who are used to playing in front of small home audiences, even without restrictions. We, therefore, urge future researchers to assess our findings' generality using different samples, and to confirm (or refute) the detected relationships as well as their potential dependence on other variables.

Our fourth key finding is that average stadium filling had an effect in Allsvenskan but not the Premier League. Again, differences between the leagues might partly explain these results. The range of stadium filling percentage was 89—99 % (CV = 6 %) -in the Premier League and 11—80 % (CV = 29 %) in Allsvenskan. Thus, the absence of a significant effect in the Premier League may have been due to most of the players being used to playing in highly filled stadiums, while the effects detected in Allsvenskan may have been at least partly due to the large variation in stadium-filling. So, in a similar manner to the putative effects of attendance numbers, audience density might modulate the social facilitation effects in football when players' experiences of playing in filled stadiums differ.

The fifth key finding is that the relative team strength of the opponent compared to the players team moderated performance without an audience in Allsvenskan but not in Premier League. When players faced better teams playing without an audience increased performance for players in teams that were ranked to be worse than the opponent whereas the players facing worse teams performed better with an audience. Atkinson's theory posits that performance depends on the perceived probability of success and the incentive value of achieving it (Atkinson, 1964). In the Premier League, players perform worse without a crowd and better in games facing worse opponents without the interaction of the opponent. That does not go in line with the theory. By contrast, in Allsvenskan, players in weaker teams and better teams get the proposed effect. One explanation could be that teams that are ranked low in Allsvenskan also have lower attendance and lower percentage of filled stadiums. The effects could therefore come from one of these variables. Further studies on this is needed.

Interestingly, neither the team's strength nor players' ages affected the difference in performances between matches with and without an audience in either league. The consistent findings in both the Premier League and Allsvenskan indicate that player age does not moderate social facilitation effects.

Strengths

Due to the COVID-19 pandemic, real competitive games could be used in our quasi-natural experimental design. Thus, the study provides complementary findings to those of research conducted in experimental settings, where conditions often lack ecological validity (Kihlstrom, 2021). Before the pandemic, few games were played without an audience and there were no sustained periods of playing without spectators. As the pandemic continued, researchers took increasing interest in the opportunities it provided to test team-level effects of factors such as audience presence and home field advantage in football. Various authors have also examined differences in individual performances with and without an audience in several sports, including football (Blomqvist Mickelsson & Shaw, 2020; Massimiliano Ferraresi & Gucciardi, 2023; Greve, et al., 2023; Heinrich, et al., 2021; Reade, et al., 2020). Nevertheless, our study is the first to exploit opportunities the COVID-19 pandemic provided to examine audience effects on individual players' performance in football games, and it may hopefully serve as a guide for future research.

Additional strengths of this study lie in the type and magnitude of data collected, which provided comprehensive samples with sufficient statistical power for multi-level mixed linear modelling with consideration of nested effects to avoid sources of potential bias. Tests indicated that three-level models were not necessary, and the flexibility of the obtained models enabled inclusion of multiple variables and use of every data point, without aggregation (e.g., use of mean values). Within the inherent limitations of using archival data, we identified variables that could potentially confound or moderate possible effects of audience presence on player performance. Inclusion of these variables enabled us to capture some of the complexity of social facilitation and its effects on player performance.

Furthermore, our outcome variable, total points per minute, was based on the concept of expected goals, which is widely used today in elite football and considered a superior indicator of actual performance than match outcome (Brechot & Flepp, 2020). The accuracy of the player performance measures gives additional weight to our findings.

Limitations

In naturalistic environments myriads of variables affect observed phenomena. Player performance in football depends on multiple factors, and accounting for all of them is impossible. Thus, many other possible variables of interest had to be neglected in this study. As already outlined, results have indicated that effects of the presence of others on performance depends on the complexity of observed tasks (Bond & Titus, 1983; Strauss, 2002). Our data and research design where performance was aggregated within games did not allow classification of the complexity of players' tasks, but theoretically the raw data could be used for such purposes, by avoiding aggregation of values for actions within games. Therefore, replicating this study using performance values for distinct actions within games would be one way to include task complexity as a potential mediating variable.

Furthermore, even if the performance outcome is based on probability to score, create chances and preventing changes from happening this outcome is not without its flaws. The positioning of the players and the individual actions importance within the games played could for example not be accounted for in this study (Pulis, 2023).

Studies on the effects of the pandemic has also highlighted several aspects that have hindered individual athletes performance. These include potential worries about the current pandemic situation (Hoteit, et al., 2024), general differences in socializing (Maruyama, et al., 2021), different daily training routines (Nakisa & Rahbardar, 2021). Therefore there is a risk that performance differences are caused by these aspects as well as social facilitation. This was not possible to control for in the current study but the differences in performance change between leagues as well as teams with different characteristics within leagues would at least to some degree point to social facilitation as a part of the differences in performance with and without an audience.

Previous research has also emphasized the potential importance of personality (Graydon & Murphy, 1995; Uziel, 2007) and gender (Heinrich, et al., 2021) as moderators of social facilitation. However, due to the limitations of available archival data we could not include either gender or personality as moderating variables.

Another possible objection is linked to the changeable nature of football, as changes in coaches and tactical instructions can lead to variations in players' performances over time. Arguably, changes in individuals' performances over time could be a consequence of changes in the game itself, rather than a result of playing with or without audience. The amount of data, however, limits the impact of occasional changes in coaches or tactical dispositions. Furthermore, we included data with spectators present from two periods of time (before the pandemic broke out and after restrictions were eased), thus minimizing risks of systematic changes in football affecting the results.

An additional limitation in interpreting the results comes from the observed deviations from normality of residuals' distributions and linearity in players' performance scores. However, mixed linear models have been shown to be remarkably robust to such violations, and hence likely to provide fairly accurate estimations (Schielzeth et al., 2020).

Practical implementations and future research

For practitioners in elite football environments, knowledge that playing in front of audiences can influence performance differently for different individual players. Especially when modern performance data is available. When recruiting players from smaller clubs or lower leagues how to handle audience can be one aspect to work with. Further, the opposite knowledge that teams as well as individuals that are very skilled may need to work with their motivation when being the favourite. This knowledge and using data may help coaches and sports psychologists to prepare players when audience circumstances are about to change. For example, by adding psychological aspects both on team level (i.e. psychological safety, coach tactics) and on individual level (i.e. personality, nervousness or perceived pressure to perform).

However, it is not clear when a difference in total points per minute becomes sufficiently large to influence actual performance noticeably and change the outcome of games. We recommend future research to further examine the practical implementations of our findings, as well as the underlying mechanisms of the observed effects.

Conclusions

Despite this study's limitations, we feel confident to conclude that the results show that the presence/absence of an audience can affect individual players' performance in football, and the relationship is not straightforward. Furthermore, the results indicate that the effect can be moderated by playing home or away, audience size and audience density. The study is the first to examine social facilitation effects on individual football players' performance and adds new insights into social facilitation. We urge future researchers to investigate the underlying mechanisms of the detected effects more thoroughly, and when doing so make sure somebody is watching.

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