Elite Players' Perceptions of Football Playing Surfaces: A Mixed Effects Ordinal Logistic Regression Model of Players' Perceptions.

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ABSTRACT: The aim of this study was to determine potential explanatory factors that may be associated with different attitudes amongst the global population of elite footballers to the use of different surfaces for football. A questionnaire was used to capture elite football players' perceptions of playing surfaces and a mixed effects ordinal logistic regression model was used to explore potential explanatory factors of players' perceptions. In total, responses from 1,129 players from 44 different countries were analysed. The majority of players expressed a strong preference for the use of Natural Turf pitches over alternatives such as Artificial Turf. The regression model, with a players' country as a random effect, indicated players were less favourable towards either Natural Turf or Artificial Turf where there was perceived to be greater variability in surface qualities or the surface was perceived to have less desirable properties. Player's surface experience was also linked to their overall attitudes, with a suggestion that the quality of the Natural Turf surface players experienced dictated players' support for Artificial Turf.

Introduction

Outdoor playing surfaces used in football (soccer) can take many different forms, including natural grass (herein termed "Natural Turf (NT)"), gravel or synthetic surfaces (herein termed "Artificial Turf (AT)"). The different playing surfaces used in the game have provoked debate amongst players and those involved in the game for several years. Early versions of Artificial Turf used for football in the 1980s were described as being hard and abrasive [4] and there were concerns that teams playing their home games on a pitch that consisted of an earlier version of Artificial Turf had an unfair home advantage (Barnett & Hilditch, 1993). Since the late 1990s there have been many developments in Artificial Turf technology with the mechanical properties of artificial surfaces better simulating Natural Turf [4]. Consequently Artificial Turf has been re-introduced as an approved surface for use in training and competition at all levels of the game, providing the pitch has been certified by FIFA (Fèdèration Internationale de Football Association) the world governing body for football.

Despite improvements in Artificial Turf there still remain mixed perceptions amongst players towards its use in football, particularly with regard to injuries, style of play [1,11] and ball behaviour [3]. Zanetti *et al.* [10] reported favourable perceptions towards Artificial Turf compared to Natural Turf in terms of ball behaviour and style of play, whilst Martinez *et al.* [6] reported favourable perceptions of players towards Natural Turf than Artificial Turf with regard to ball behaviour and fatigue. Player's perceptions of overall comfort were also reported to differ between Artificial Turf surfaces with varying mechanical properties but their perception of physical effort did not differ despite changes in physical performance measures [9]. These contrasting outcomes suggest that differing attitudes may exist amongst different cohorts of players and could be explained by many different factors. Possible factors that could explain differences in players' perceptions reported in the literature include ability level [3], gender [1], playing position [5], age and surface experience [3,5]. Previous research has only been able to explore potential explanatory factors on a small cohort of players, often from a single country and there is a need to explore the explanatory factors of players' perceptions on a global level.

A recent qualitative study of elite football players' perceptions of playing surfaces by [7] identified several themes which were important to players and also identified potential explanatory factors. The qualitative study was conducted with players from a small sample of European countries, and it was deemed necessary to quantitatively explore these key themes and explanatory factors across a wider elite footballing population to determine

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whether the attitudes expressed by these players were similar across the globe [7].

The aim of this study, therefore, was to determine potential explanatory factors that may be associated with different attitudes amongst the global population of elite footballers to the use of different surfaces for football.

Methodology

A questionnaire was used to capture responses from players on a range of aspects relating to their experience and perceptions of four different playing surfaces: Natural Turf, Artificial Turf, and Gravel and Indoor surfaces. For the purposes of this study, the term 'Artificial Turf' was used in the questionnaire to refer to any synthetic surface as it was unlikely that the players had only experienced certified Football Turf pitches. The questionnaire was divided into six parts which covered the key themes that were identified by elite players during the initial qualitative study reported on by Ronkainen *et al*. [7]. The present study focuses on information gathered in Parts 3, 5 and 6 of the questionnaire (Figure 1).

Part 3 of the questionnaire gathered information on the players' experiences of four different surfaces, "Natural Turf", "Football Turf," "Gravel or similar hard surface" and "Indoor Sports Hall", each in the context of training or playing matches and at two different stages in their careers, juniors and seniors. Part 5 of the questionnaire captured players' perceptions of the variation in properties between different AT pitches and also between different NT pitches. Part 5 also included statements with direct comparisons between NT and AT properties. Finally, Part 6 of the questionnaire included a series of sentiments which were expressed by elite players during the initial qualitative study [7] and players were asked to respond with their level of agreement (Figure 1).

Players were included in the study by means of a pragmatic non-random cluster sampling approach such that a convenience sample of clubs from within all six FIFA confederations could be visited within the time and costs constraints. Also included were players taking part in a small number of tournaments organized by FIFPro (the professional players' organisation) taking place during the periods when these countries were visited. These clubs and tournaments were then visited by a member of the study team in order to collect the data locally via the questionnaire.

According to the FIFA Big Count (2006), there were 112,000 registered professional players worldwide. In this study, a total of 1,129 elite players' responses from 44 countries were analysed. These countries are listed in the Appendix (grouped by the six FIFA confederations), along with summary statistics describing the age and gender of players within each country. The overall age distribution of the players in the study ranged from 18 to 39 years with

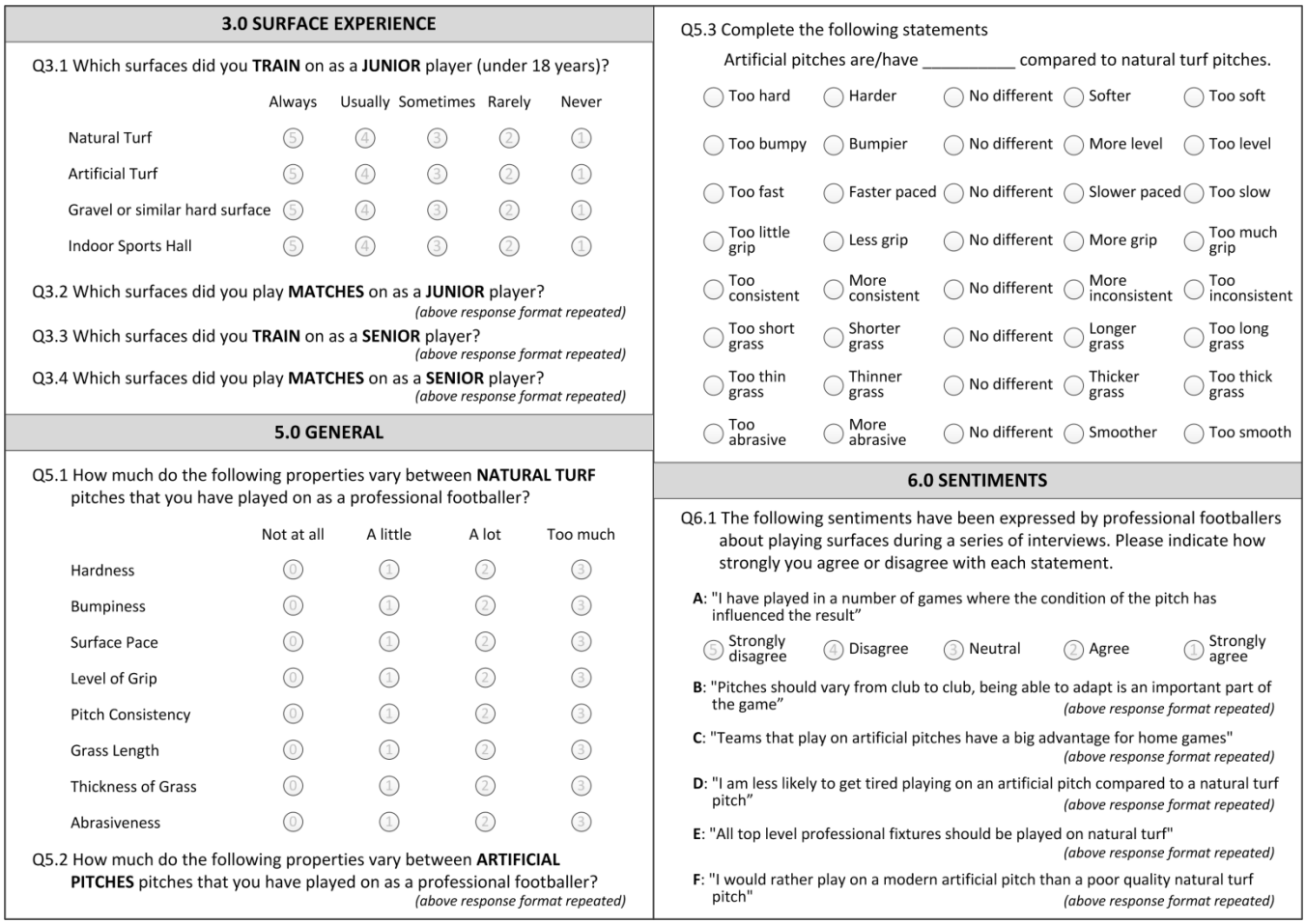

Figure 1. Example question formats and themes for Parts 3, 5 and 6 of the questionnaire.

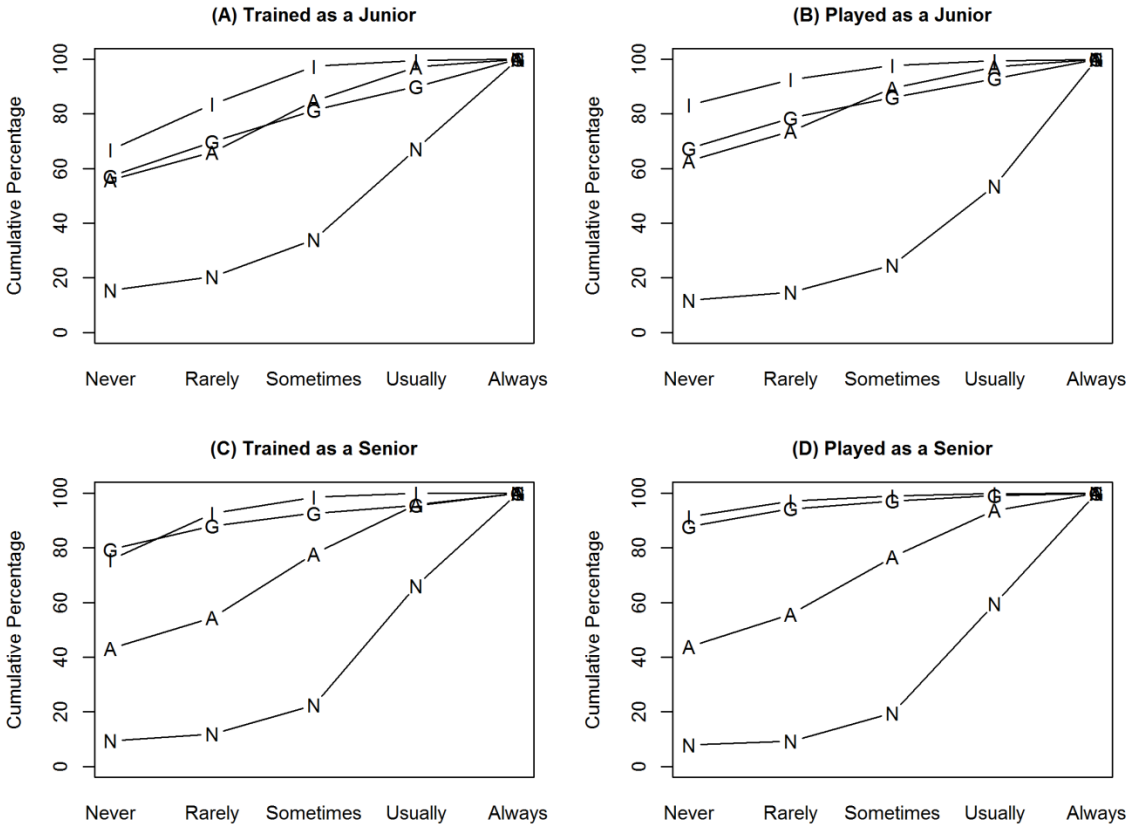

Figure 2. Cumulative percentage distributions of responses for players' surface experience (N=Natural Turf, A=Artificial Turf, G=Gravel or similar, I=Indoor).

a mean of 24.9 years (SD=4.57 years), these ages being distributed similarly across each confederation, and the sample included players playing in all positions. This is the largest and only international survey of its kind and so the data set complied from this study offers a potentially very important contribution to the debate regarding players' perceptions of different playing surfaces. The sample included data from both male players (1,018) and female players (111), although no attempt is made to consider gender in this study due to the fact that the female players are concentrated in only a small number of countries.

Players' surface experience on each of four surfaces in training or playing matches and at junior or senior level is summarised in Figure 2. These show the cumulative percentage distributions of responses, which were recorded as "Never", "Rarely", "Sometimes", "Usually" or "Always". This illustrates, perhaps as expected, that Natural Turf dominates with higher proportions of players responding with "Usually" or "Always" on this surface. However, Figure 2 also illustrates that Football Turf features more prominently as a senior, both in training and play situations, compared to as a junior, and also highlights the limited amount of time that indoor surfaces feature.

Overall Player Responses to Sentiments

The distributions of responses to each of the six sentiments are summarized in Figure 3. One sample Wilcoxon tests (used to compare each sentiment individually versus a median score of 3 under the null hypothesis) revealed that the median scores were significantly different to the neutral score of 3 (p<0.001) for all six sentiments. Figure 3 indicates that in general, the majority of players tended to agree with the sentiments expressed by elite players during the initial qualitative study, apart from Sentiment D with which there was a general level of disagreement. The results for Sentiment D suggest that players, in general, disagreed that they are less likely to get tired on an AT pitch compared to an NT pitch. This is consistent with the findings of Anderson *et al*. (2008) who reported that players consider AT pitches to be more physically demanding than NT.

With regard to Sentiment A, over two-thirds of players involved in the study indicated that the condition of the pitch had influenced the outcome of a game they had been involved in. However, around a half of players felt that adapting to different pitches is a fundamental part of the game (Sentiment B), which would seem to suggest that some variation in pitch properties is acceptable to players.

Perhaps the most interesting set of results suggested by Figure 3 are those for Sentiments C, E and F. Approximately three-quarters of players felt that all top level games should be played on NT (Sentiment E), and in addition, around two-thirds of players felt that AT pitches afford the home team a big advantage (Sentiment C). However, around a half of players agreed that they would rather play on a modern AT pitch than a poor quality NT surface (Sentiment F). These results would seem to sug-

gest that, whilst there is a general preference for NT, this preference is dependent on the quality of that NT surface. Sentiments C, E and F therefore become the focus of the remainder of the paper where we explore whether there are any potential factors within our data set to explain the differences of opinion between players.

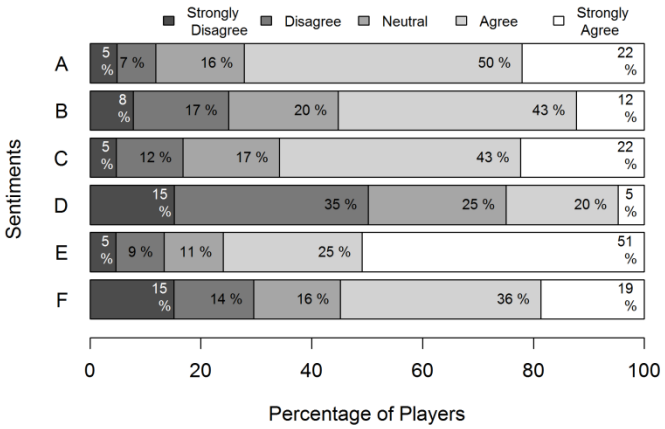

Figure 3. Distribution of players' responses to the six sentiments
A = I have played in a number of games where the condition of the pitch has influenced the result
B = Pitches should vary from club to club, being able to adapt is an important part of the game
C = Teams that play on Football Turf pitches have a big advantage for home games
D = I am less likely to play on an artificial pitch compared to a natural turf pitch
E = All top level fixtures should be played on Natural Turf
F = I would rather play on a modern Football Turf pitch rather than a poor quality Natural Turf pitch

Explanatory Factors of Player Responses to Sentiments

Exploratory analyses in the present study together, with the results from the initial qualitative study, suggested consideration of the following four explanatory factors in our models: (i) geographical location, (ii) players' actual previous experience of different types of surfaces, (iii) the variation in the properties of different surfaces players have experienced and (iv) players' perceptions of the properties of AT pitches compared to NT pitches. For (i), the players' country where they are currently playing was used as a potential explanatory factor in the model.

With regard to (ii) however, the use of players' responses to the 16 questions on surface experience as potential explanatory factors in an ordinal logistic regression model, presented problems relating to multicollinearity as well as parsimony and stability of the parameter estimates. To resolve both of these issues, a Principal Components Analysis (PCA) was undertaken with polychoric correlations (due to the ordinal nature of the responses to the surface experience questions), undertaken using the *princomp* function within the standard installation of the R statistical software. In fact responses to the questions on players' experience of Indoor surfaces were excluded since this surface featured very rarely. Four principal components were identified (PC1, PC2, PC3 and PC4) with component loadings listed in Table 1, which together explained 87.3% of the total variation in players' responses to the remaining 12 surface experience questions. Interpreting the component loadings from Table 1 allows potentially meaningful interpretations to be attached to these four principal components as shown in Table 2. Based on these interpretations, the principal components PC1, PC2, PC3 and PC4 are referred to in the remainder of this paper as NT_{exp}, $GRvAT_{exp}$, $NT_{jun}\_AT_{sen}$ and $NT_{train}\_AT_{play}$ respectively.

With regard to (iii), for the same reasons, two separate PCA analyses were conducted on the NT and AT pitch properties separately. These suggested that for both NT and AT the responses to each set of eight questions loaded equally onto just one new principal component each. This suggested in both cases the use of a simple total of the scores across the eight questions herein referred to as NT_{var}, and AT_{var}. The reliability of these measures is supported by Cronbach's alpha values of 0.82 and 0.89 respectively (values above 0.8 are normally considered acceptable).

With regard to (iv), players' responses to the eight questions on their perceptions of AT surfaces compared to NT surfaces were treated as eight separate categorical predictors. These are herein referred to as *Hardness, Bumpiness, Pace, Consistency, Abrasiveness, Grip, GrassLength and GrassThickness*.

A Mixed Effects Ordinal Logistic Regression Model for Players' Overall Responses

Model Specification

This section uses the explanatory factors considered in the previous section to develop a model for players' responses to Sentiments C, E and F. The model used is of the form of a mixed effects ordinal logistic regression model, with country included as a random effect. We denote y_{ki} as the observed response (to a given sentiment) for player i (nested within Country k), scored as 1 for "Strongly Disagree" or "Disagree", 2 for "Neutral", and 3 for "Agree" or "Strongly Agree". The original five ordinal response categories are combined in this way since our interest lies mainly in whether players agree or disagree, and also aids interpretation of the parameter estimates in the final model. The three categories are referred to here as "Disagreeing", "Neutral" and "Agreeing" respectively. The model can then be specified in terms of the usual cumulative logits as follows:

$$\log_e\left[\frac{P(Y_{ki}\leq j)}{1-P(Y_{ki}\leq j)}\right] = \alpha_j - \mathrm{X}_{ki}\beta + u_{k,} \qquad j=1,2 \qquad (1)$$

Question	PC1	PC2	PC3	PC4
Q3.1a Trained as a Junior on Natural Turf	0.34	0.08	0.38	0.05
Q3.1b Trained as a Junior on Artificial Turf	-0.09	-0.54	-0.23	-0.24
Q3.1c Trained as a Junior on Gravel or similar	-0.33	0.22	-0.27	0.13
Q3.2a Played as a Junior on Natural Turf	0.37	0.08	0.24	-0.26
Q3.2b Played as a Junior on Artificial Turf	-0.18	-0.48	-0.14	0.19
Q3.2c Played as a Junior on Gravel or similar	-0.36	0.21	-0.19	0.23
Q3.3a Trained as a Senior on Natural Turf	0.33	0.09	-0.21	0.51
Q3.3b Trained as a Senior on Artificial Turf	-0.20	-0.40	0.30	-0.25
Q3.3c Trained as a Senior on Gravel or similar	-0.31	0.35	-0.01	-0.33
Q3.4a Played as a Senior on Natural Turf	0.30	-0.01	-0.47	-0.24
Q3.4b Played as a Senior on Artificial Turf	-0.26	-0.09	0.48	0.43
Q3.4c Played as a Senior on Gravel or similar	-0.25	0.28	0.13	-0.31

Table 1. Principal component loadings.

PC	*Description*
PC1: NT_{exp}	Larger positive values are associated with players who have more experience of NT and less experience of other surfaces such as AT or Gravel, and vice-versa giving larger negative values. Hence this principal component appears to reflect a measure of players' experience on NT.
PC2: $GRvAT_{exp}$	Larger positive values are generally associated with players who have more experience of Gravel and less experience of AT, and vice-versa giving larger negative values. Hence this principal component appears to reflect a contrast between players with more Gravel experience (positive values) versus those with more Artificial Turf experience (negative values).
PC3: $NT_{jun}\_AT_{sen}$	Larger positive values are mainly associated with players who as a junior had more experience of NT, but as a senior have more experience of AT. Larger negative values are mainly associated with players who as a junior had more experience of AT but as a senior have more experience of NT. Hence this principal component appears to mostly reflect a measure of the extent to which players' surface experience changed between NT and AT, and in which direction during the transition between a junior to a senior. Gravel does also feature somewhat in this component but to a lesser extent.
PC4: $NT_{train}\_AT_{play}$	Larger positive values are mostly associated with players who train more on NT but play more on AT. Larger negative values are mostly associated with players who train more on AT but play more on NT. Hence this principal component reflects a measure of the extent to which players' experience of NT and AT differed between playing and training.

Table 2. Interpretations of first four principal components.

Model	Sentiment C				Sentiment E				Sentiment F			
	AIC	R^2	χ^2_7	p	AIC	R^2	χ^2_7	p	AIC	R^2	χ^2_7	p
0	1894.3	0.067	63.10	<0.001	1483.2	0.130	115.35	<0.001	1884.7	0.274	296.45	<0.001
			χ^2_4				χ^2_4				χ^2_4	
1 Hardness	1890.9	0.079	11.42	0.022	1443.4	0.181	47.76	<0.001	1848.1	0.310	44.62	<0.001
2 Bumpiness	1898.1	0.071	4.20	0.38	1479.2	0.143	11.93	0.018	1881.5	0.283	11.17	0.025
3 Pace	1898.3	0.071	3.76	0.44	1465.9	0.157	24.94	<0.001	1877.5	0.286	14.44	0.006
4 Consistency	1885.7	0.084	16.33	0.0026	1471.8	0.151	19.03	<0.001	1856.1	0.303	35.86	<0.001
5 Abrasiveness	1898.1	0.071	4.22	0.38	1473.6	0.149	17.56	0.0015	1872.7	0.290	20.00	<0.001
6 Grip	1899.6	0.070	2.68	0.61	1480.9	0.141	10.29	0.036	1886.9	0.279	5.85	0.21
7 Grass Length	1895.3	0.074	6.98	0.14	1485.6	0.136	5.54	0.24	1886.0	0.280	6.71	0.15
8 Grass Thickness	1888.2	0.082	14.11	0.0069	1453.0	0.171	38.15	<0.001	1868.9	0.293	23.81	<0.001

R^2 shown is Nagelkerke and χ^2 shown is log-likelihood ratio statistic

Sentiment C = Teams that play on Football Turf pitches have a big advantage for home games

Sentiment E = All top level fixtures should be played on Natural Turf

Sentiment F = I would rather play on a modern Football Turf pitch rather than a poor quality Natural Turf pitch

Table 3. Model Fit Results

The term $P(Y_{ki} \leq j)$ represents the probability that player i (in Country k) responds to a sentiment with a category score of j or lower (j = 1, 2). Note that the logit is not defined here for j = 3 since $P(Y_{ki} \leq 3)$=1. The odds ratio (OR) $P(Y_{ki} \leq j) / [1-P(Y_{ki} \leq j)]$ therefore represents the usual (ordinal) odds that player i (in Country k) responds to a sentiment with a category score of j or lower. For example, this could refer to the odds that a player agrees with the sentiment compared to being neutral or disagreeing.

The term X_{ki} denotes the relevant data from the explanatory variables for player i in Country k, whilst the term β denotes the vector of model parameters. The negative sign in front of $X_{ki}\beta$ ensures that positive parameter estimates suggest that increasingly positive values of an explanatory variable are associated with a higher probability of a player agreeing with the sentiment. The term u_k represents the random effect for Country k, where $U \sim N(0,\sigma^2)$ whilst the α_j are "threshold" parameters which simply serve as "intercepts" in the model.

We are interested in whether the model provides support for the assertion made earlier that differences in players' responses to Sentiments C, E and F are at least in part due to:

(i) Differences between countries;

(ii) Players' actual previous experience of different types of surfaces (NT_{exp}, $GRvAT_{exp}$, $NT_{jun\_}AT_{sen}$, $NT_{train\_}AT_{play}$);

(iii) Variation in the properties of the different surfaces players have experienced (NT_{var} and AT_{var});

(iv) Players' perceptions of the differences in the properties of NT and AT pitches (*Hardness, Bumpiness, Pace, Consistency, Abrasiveness, Grip, Grass Length and Grass Thickness*).

The continuous variables in (ii) and (iii) above were also standardized in the model to have zero mean and unit variance when included later in the model. A consequence of treating the eight pitch property comparison variables in (vi) as categorical, is that the inclusion of all of these variables in one model leads to the need to estimate 32 additional parameters (four levels for each of the eight variables). Therefore, again for reasons relating to model parsimony/stability issues, and also potential multicollinearity issues, these eight pitch property comparison variables were only included in the model one at a time in isolation. A total of 9 models (referred to as Models 0 to 8) were fitted for each of the three original senti-

ments (C, E and F). Model 0 includes Country as a random effect, along with NT_{exp}, $GRvAT_{exp}$, $NT_{jun}\_AT_{sen}$, $NT_{train}\_AT_{play}$, NT_{var} and AT_{var}. Models 1 to 8 are the same as Model 0 plus just one of the eight surface comparison variables; *Hardness, Bumpiness, Pace, Consistency, Abrasiveness, Grip, Grass Length* and *Grass Thickness*, respectively. In each case, the base level for each pitch property comparison variable was set as the "No Difference" category, so that the significance of the parameter estimates for other levels of these categorical variables could be contrasted against that baseline. These models are an example of Cumulative Link Mixed Models and were fitted using the *clmm* and *clmm2* functions available within the *ordinal* package in the R statistical software.

Results

We first consider the model fit results in Table 3. For all three sentiments, Model 0 was statistically significant ($p<0.001$) with respect to likelihood ratio tests. However, the explanatory variables considered in Model 0 account for more of the variation in players' responses to Sentiment (R^2 Nagelkerke = 0.274), compared to Sentiments E (R^2 Nagelkerke = 0.130) and C (R^2 Nagelkerke = 0.067). Model fit, as described by the AIC and likelihood ratio tests, was often improved for all three sentiments with the addition of the eight surface comparisons of pitch properties. Of these pitch properties; *Hardness, Consistency, Pace, Abrasiveness* and *Grass Thickness* appear to be the most important factors.

Since Sentiment F contains a direct comparison between AT and NT and also includes reference to the condition of an NT pitch, it is perhaps to be expected that experience of different surfaces, perceptions of surface variability and their different characteristics are more likely to be appropriate explanatory factors that result in the strongest model fit. In contrast, Sentiment C relates more to a player's specific experience of competitive fixtures on AT pitches; as a third of players in the sample reported that they had never played a competitive game on AT at junior or senior level, it is perhaps to be expected that the explanatory variables used don't explain their responses to this particular sentiment quite so well. Given the greater strength of model fit and for brevity and space reasons, for the remainder of this paper only Sentiments E and F will be discussed.

Table 4 shows the resulting parameter estimates (Est.) from the respective models, along with their associated odds ratios (OR). Also shown are 95% confidence intervals for the estimate of σ and the odds ratios, all obtained from their respective profile likelihood. Parameter estimates that are statistically significant are shown in bold and highlighted using an asterisk notation. In this section we discuss the interpretation of these parameter estimates for each set of explanatory factors (random country effect, surface experience, variation in pitch properties and surface property comparisons). In Section 5.3 we attempt to illustrate the magnitude of any effects of the explanatory factors on players' responses by directly considering the predictive probabilities arising from the model(s).

Random Country Effect

The significant parameter estimates for σ for both sentiments suggests there is additional residual between-country variation ($p<0.001$) that is not explained by the explanatory variables included in the models considered here. This residual variation could be due to other factors not included in the models, or could reflect differences between countries that may relate to purely cultural or other differences or may be just random variation in players' responses, or indeed a mixture of both.

Surface Experience

Players' responses to both sentiments E and F appear to be associated with differences in surface experience.

For Sentiment E, the lack of significance for NT_{exp} (Table 4) suggests that players' previous experiences of NT has little effect on their views on the use of NT pitches in all top level fixtures. Table 4 indicates that the only significant surface experience factor with this sentiment was GRvAT*exp* with an odds ratio of 0.83 (95% CI = 0.69 to 0.99). Although a borderline result, this suggests that where players' surface experience (away from NT) is based more on gravel and less on AT, then they are less likely to agree with the use of NT pitches in all top level fixtures. One possible interpretation of this result is, if it can be assumed that the hard gravel surfaces players have experienced are in fact poor quality NT surfaces then this would suggest that there is less support for NT where the quality of that surface deteriorates.

Players' responses to Sentiment F appear to be explained more by differences in surface experience, with significant factors associated with NT_{exp}, $GRvAT_{exp}$ and $NT_{jun}\_AT_{sen}$. The odds ratio of 0.73 for NT_{exp} (95% CI = 0.61 to 0.87) suggests that players with more NT experience are less in favour of switching to AT over a poor quality NT pitch. This might be due to a bias in favour of NT amongst those players that play more regularly on NT, or it could be due to the fact that, players who play more regularly on NT pitches, do so on better quality pitches. The odds ratio of 1.20 for $GRvAT_{exp}$ (95% CI = 0.99 to 1.42), which is a borderline result but provides some suggestion that irrespective of the extent of their NT experience, players with more experience of gravel pitches are more inclined to use AT over a poor quality NT pitch. Again, if it can be assumed that the hard gravel surfaces players have experienced are in fact poor quality NT surfaces, then this would add further support to the assertion that there is less support for NT where the quality of that surface deteriorates and some players would opt to use an AT pitch instead. The odds ratio of 1.24 for $NT_{jun}\_AT_{sen}$ (95% CI = 1.06 to 1.45) suggests that players who have had more experience of AT in their senior careers and less as a junior, are also more inclined to use AT over a poor quality NT pitch.

Model Term	*Model Parameter*	*Sentiment E*					*Sentiment F*				
		Est.		*p*	CI		Est.		*p*	CI	
Country (Model 0)	σ	**0.98**		***	**0.69**	**1.41**	**1.21**		***	**0.89**	**1.69**
		Est.	*p*	O.R.	C.I.		Est.	*p*	O.R.	C.I.	
Thresholds (Model 0)	α_1	**-2.29**	***	**0.10**	**0.07**	**0.15**	**-1.41**	***	**0.25**	**0.16**	**0.38**
	α_2	**-1.47**	***	**0.23**	**0.16**	**0.34**	**-0.50**	*	**0.61**	**0.39**	**0.93**
Surface Experience (Model 0)	NT_{exp}	0.05		1.05	0.87	1.27	**-0.32**	***	**0.73**	**0.61**	**0.87**
	$GRvAT_{exp}$	**-0.19**	*	**0.83**	**0.69**	**0.99**	**0.18**	*	**1.20**	**0.99**	**1.42**
	$NT_{jun}\_AT_{sen}$	-0.04		0.96	0.82	1.14	**0.21**	**	**1.24**	**1.06**	**1.45**
	$NT_{train}\_AT_{play}$	-0.09		0.91	0.77	1.08	0.07		1.07	0.91	1.25
Pitch Variation (Model 0)	NT_{var}	-0.12		0.88	0.75	1.04	**0.30**	***	**1.35**	**1.17**	**1.57**
	AT_{var}	**0.34**	***	**1.41**	**1.19**	**1.67**	**-0.26**	***	**0.77**	**0.67**	**0.89**
Hardness (Model 1)	Too Hard	**1.69**	***	**5.39**	**2.9**	**10.02**	**-0.65**	*	**0.52**	**0.29**	**0.93**
	Harder	**1.10**	***	**3.01**	**1.74**	**5.19**	0.19		1.21	0.70	2.10
	Softer	0.12		1.12	0.59	2.13	**0.98**	*	**2.66**	**1.24**	**5.71**
	Too Soft	1.23		3.42	0.58	20.24	-0.98		0.37	0.08	1.83
Bumpiness (Model2)	Too Bumpy	0.66		1.93	0.93	4.02	-0.33		0.72	0.41	1.25
	More Bumpy	0.34		1.40	0.79	2.49	0.05		1.05	0.65	1.72
	More Level	-0.16		0.85	0.51	1.41	0.37		1.45	0.94	2.25
	Too Level	0.42		1.52	0.63	3.65	0.09		1.09	0.53	2.25
Pace (Model 3)	Too Slow	**2.16**	*	**8.68**	**1.06**	**70.89**	-0.40		0.67	0.22	2.04
	Slower	**0.94**	**	**2.55**	**1.42**	**4.59**	0.22		1.24	0.77	2.01
	Faster	0.01		1.01	0.63	1.63	**0.48**	*	**1.62**	**1.05**	**2.48**
	Too Fast	0.64		1.89	0.99	3.63	-0.21		0.81	0.47	1.39
Consistency (Model 4)	Too Inconsistent	**1.46**	***	**4.29**	**2.03**	**9.05**	**-0.70**	**	**0.50**	**0.29**	**0.83**
	More Incon-sistent	0.26		1.29	0.82	2.04	**0.45**	*	**1.57**	**1.02**	**2.42**
	More Consistent	0.46		1.58	1.00	2.49	0.12		1.13	0.74	1.72
	Too Consistent	**0.68**	*	**1.97**	**1.07**	**3.63**	**-0.63**	*	**0.53**	**0.32**	**0.90**
Abrasiveness (Model 5)	Too Abrasive	0.05		1.05	0.61	1.82	-0.21		0.81	0.50	1.33
	More Abrasive	-0.14		0.87	0.57	1.32	**0.54**	**	**1.72**	**1.19**	**2.48**
	Smoother	**0.95**	**	**2.60**	**1.35**	**5.00**	0.26		1.30	0.82	2.07
	Too Smooth	0.71		2.03	0.7	5.92	-0.32		0.72	0.35	1.52
Grip (Model 6)	Too Little Grip	**0.59**	*	**1.80**	**1.08**	**3.00**	-0.22		0.80	0.51	1.25
	Less Grip	**0.40**	*	**1.49**	**1.01**	**2.19**	0.10		1.11	0.78	1.58
	More Grip	**0.71**	*	**2.04**	**1.04**	**4.01**	-0.07		0.93	0.53	1.63
	Too Much Grip	-0.75		0.47	0.13	1.72	-1.07		0.34	0.09	1.27
Grass Length (Model 7)	Too Short	0.39		1.48	0.53	4.09	-0.64		0.53	0.23	1.20
	Shorter	0.45		1.57	0.98	2.50	-0.07		0.93	0.63	1.37
	Longer	0.04		1.04	0.69	1.58	0.03		1.03	0.71	1.51
	Too Long	0.30		1.35	0.80	2.27	-0.40		0.67	0.42	1.05
Grass Thickness (Model 8)	Too Thin	**1.23**	***	**3.41**	**2.04**	**5.71**	**-0.44**	*	**0.64**	**0.41**	**1.00**
	Thinner	**1.03**	***	**2.80**	**1.83**	**4.26**	0.08		1.09	0.73	1.61
	Thicker	0.23		1.25	0.79	1.98	**0.66**	**	**1.94**	**1.21**	**3.13**
	Too Thick	-0.20		0.82	0.33	2.06	0.27		1.32	0.47	3.65

* 0.05>p≥0.01, ** 0.01>p≥0.001, *** 0.001>p

Table 4. Parameter estimates

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Variation in Pitch Properties

Table 4 also suggests that players' responses to both sentiments E and F appear to be associated with the variability in the NT and AT pitches they have experienced. For Sentiment F, the odds ratio of 1.35 for NT_{var} (95% CI = 1.17 to 1.57) suggests that where players have experienced greater variability in NT surfaces they are more likely to be in favour of using AT over a poor quality NT pitch. With regard to AT_{var}, the odds ratios associated with Sentiments E and F of 1.41 (95% CI = 1.19 to 1.67) and 0.77 (95% CI = 0.67 to 0.89) respectively, provides evidence that players who have experienced greater variability in AT surfaces are more likely to prefer the use of NT in all top level fixtures and are less likely to be open to the use of AT even where the NT surface is of a poor quality.

These results suggest that players who have experienced greater variability in NT surfaces are more likely to consider AT a viable alternative, whereas players who have experienced greater variability in AT pitch properties have stronger preferences towards NT. Despite the apparent general agreement with Sentiment B reported earlier, that "Pitches should vary from club to club, being able to adapt is an important part of the game", the above results suggests that in fact greater variation in pitch properties is considered a negative factor amongst players.

Surface Property Comparisons

Tables 3 and 4 also indicate how players' perceptions of the differences in pitch properties between NT and AT is related to their overall perceptions of playing surfaces. The eight surface comparison variables, *Hardness, Bumpiness, Pace, Consistency, Abrasiveness, Grip, Grass Length* and *Grass Thickness*, are assessed in Models 1 to 8 respectively. For Sentiments E and F, the most important of the eight surface comparison variables seem to be *Hardness, Consistency, Pace, Abrasiveness* and *Grass Thickness*.

The addition of Hardness provided the largest improvements in model fit (as described by the AIC and likelihood ratio tests) and also gave the largest R^2 and smallest AIC (Table 3) for both sentiments, suggesting this has the greatest impact on players' opinions. For Sentiment E, Table 4 shows that all the statistically significant odds ratios are greater than 1, suggesting that players are more likely to agree with the use of NT in all top level fixtures whenever they perceive AT pitches (when compared to NT pitches) as being "Harder" (or "Too Hard"), "Slower" (or "Too Slow"), "Too Inconsistent" or "Too Consistent", "Smoother", having "Less Grip" (or "Too Little Grip") or having grass that is "Thinner" (or "Too Thin"). Evidence from the initial qualitative study [7] indicates that many of these are negative traits associated with a playing surface. It should be noted that there is a poor estimate of the effect of when players perceive AT pitches as Too Slow (OR = 8.68, 95% CI = 1.06 to 70.89), which is due to the fact that almost all (21 out of 22) players who felt AT pitches are too slow also agreed with Statement E.

For Sentiment F, where the statistically significant odds ratios are greater than 1, these suggest that players are more likely to agree with the use of AT pitches over a poor quality NT pitch whenever they perceive AT pitches (compared to NT pitches) as being "Softer", "Faster", "More Inconsistent", "More Abrasive", or having "Thicker Grass". Most of these ("Softer", "Faster", and "Thicker Grass") were also considered positive attributes of a pitch in the qualitative study [7], which seem to suggest further evidence of a preference towards the surface that is perceived to be "better" with respect to the properties discussed. With regard to "Consistency" and "Abrasiveness", it wasn't clear why players might prefer a surface which is "More Inconsistent" or "More Abrasive". One possible explanation could be that where players view AT pitches as "different" to NT pitches (e.g. "More Abrasive" or "Smoother") but not too extreme (e.g. not "Too Abrasive" or "Too Smooth), then the direction of the odds ratios seem to suggest greater agreement with the use of AT pitches over a poor quality NT pitch.

For Sentiment F, there are also statistically significant odds ratios less than 1, suggesting that players are less likely to agree with the use of AT pitches over a poor quality NT pitch whenever they perceive AT pitches (compared to NT pitches) as being "Too Hard", "Too Inconsistent", "Too Consistent or where the grass is perceived as "Too Thin". The conflicting results for consistency might again be explained by the implied suggestion made above, that where players view AT pitches as too extreme ("Too Inconsistent" or "Too Consistent") then there is less agreement with the use of AT pitches over a poor quality NT pitch.

Estimated Probabilities

Discussion of the impact of explanatory factors on players' responses to the two sentiments has so far been based on whether the odds ratios are greater than or less than 1. In order to examine the magnitude of the impact that changes in the explanatory variables may have on their responses to the sentiments, Figure 4 illustrates how the estimated (model based) probabilities of players agreeing with Sentiment F varies with these explanatory variables. A separate plot is shown for each of the five continuous explanatory variables that were found to be significant in the model for this sentiment; NT_{exp}, $GRvAT_{exp}$, $NT_{jun}\_AT_{sen}$, NT_{var} and AT_{var} (using Model 0). The probabilities illustrated are calculated assuming that all other continuous explanatory variables are held constant at their mean level of zero, whilst all the categorical surface comparison variables are kept fixed at the "No Difference" level. Each plot includes three lines; one for an "Average country" where the probabilities are calculated at the conditional mode for the random country effect, and the other two which represent typical countries at the 2.5% and 97.5% percentiles from the potential global variation in players' opinions.

Figure 4(A) for example, illustrates that where players have the average amount of experience of NT (NT_{exp} = 0) then approximately 60% of those players (from an average country) would agree with the use of AT over a poor quality NT pitch. Note that average amount of NT experience is not central on the horizontal scale due to the skewed nature of players' experience on that surface. This proba-

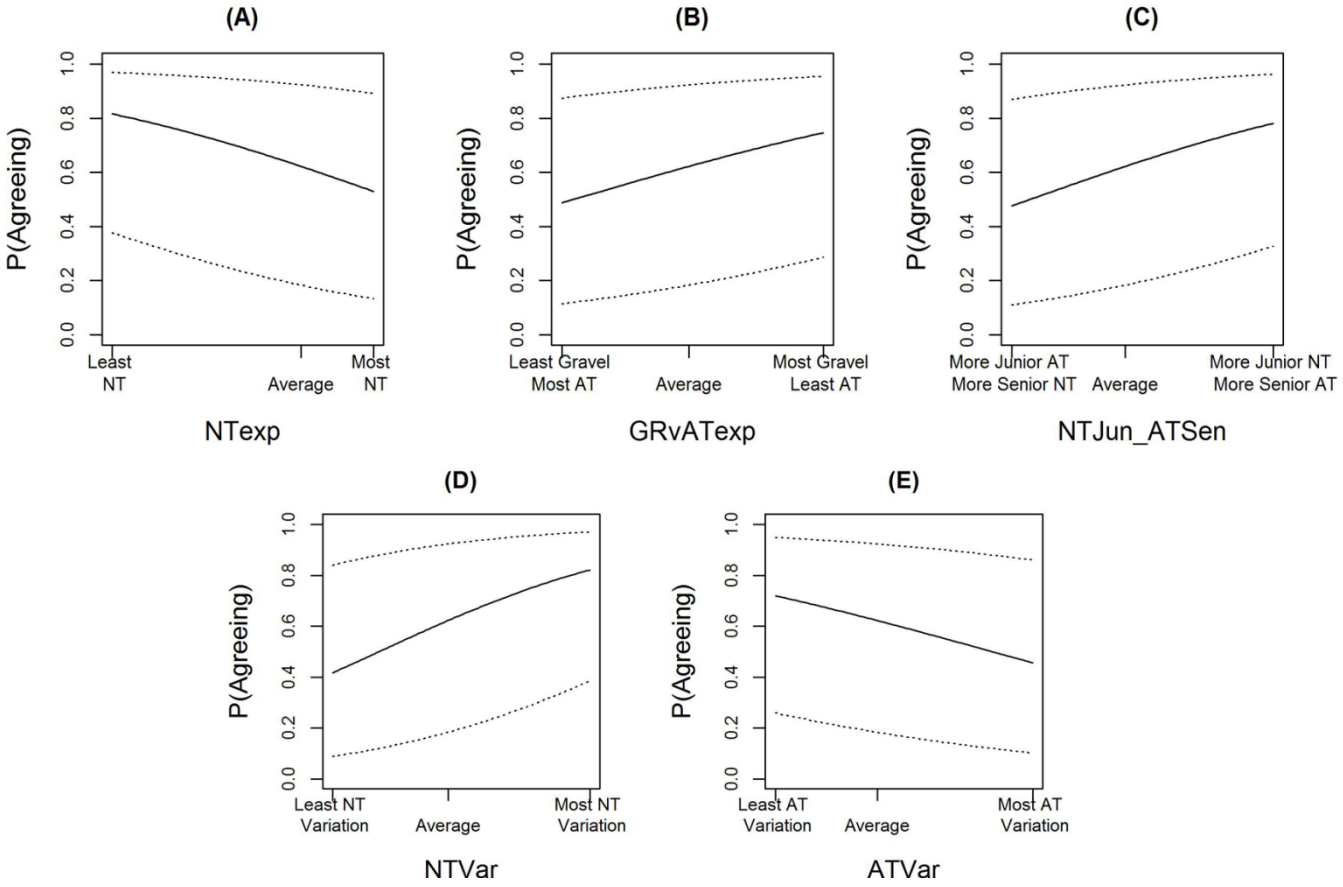

Figure 4. Estimated model probabilities of "Agreeing" with Sentiment F. (——) Average country, (⋯⋯) Lower 2.5% and upper 97.5% country percentiles

bility falls to just under 50% amongst those players who have the highest amount of NT experience, and increases to around 80% for players with the lowest amount of NT experience. However, Figure 4(A) also illustrates that there is additional variability between countries even after accounting for the explanatory variables in the model. For example, amongst players with an average level of NT experience (NT_{exp} = 0) the estimated percentage of players that would agree with the use of AT over a poor quality NT pitch ranges from as low as 18% to as much as 92% depending on the country the player was from. Similar levels of impact are seen in relation to differences in the remaining four explanatory variables in Figure 4(B) to Figure 4(E).

Model Checking

One strong assumption in the model is that of proportional odds. This assumes that the relationship between the explanatory variables and the odds ratio $P(Y_{ki} \leq j) \,/\, [1-P(Y_{ki} \leq j)]$ (for player i in Country k) is the same regardless of whether j = 1 or 2. In other words regardless of whether we are referring to the odds of disagreeing (versus neutral or agreeing) or the odds of disagreeing or neutral versus agreeing, with the sentiment being modelled. Likelihood ratio tests were undertaken to compare a fuller model, where the proportional odds for each explanatory variable was relaxed in turn, with the constrained model employed in the previous section which assumes proportional odds for all explanatory variables. These suggested that the only cases where the assumption of proportional odds may be an issue was with $GRvAT_{exp}$, AT_{var}, and *Hardness* in relation to Sentiment E, and also $GRvAT_{exp}$, *Hardness*, *Pace* and *Grass Thickness* in relation to Sentiment F. However, in all these cases, the odds ratios obtained when this assumption is relaxed were all consistent with the overall conclusions outlined in the previous section. That is the impact of the explanatory variables was in the same direction regardless of whether this is in relation to the odds of disagreeing (versus neutral or agreeing) or the odds of disagreeing or neutral (versus agreeing). Hence this has little bearing on the overall conclusions reported in the previous sections.

The issue of multicolinearity between the explanatory variables was also investigated and no issues were evident. The use of PCA (with polychoric correlation) in relation to the surface experience variables meant that the four surface experience variables have negligible pair-wise correlations. In addition, the correlation between the two pitch variation variables was negligible (0.15) and between those two variables and the four surface experience variables (correlation coefficients ranged from -0.12 to 0.15). Further evidence of the lack of multicollinearity was provided by condition numbers for model 0 which were less than 50 for both sentiments E and F, whilst for models 1 to 8 these were typically of the order of 100-200 and always less than 500. Values larger than 10^4 would indicate

potential problems. In addition no convergence issues were evident during the optimisation routines within the *clmm* or *clmm2* packages used with *R*.

The relatively low values for Nagelkerke's R^2 reported in Table 3 earlier are actually not unusual within the context of Cumulative Link Mixed models considered here, and whilst the R^2 measures from these models are useful to compare nested models as we have done, they cannot be interpreted in isolation as a measure of model fit in the same way as they are used in normal linear models. A more appropriate measure of overall fit of the models reported is provided by the extent to which the model correctly predicts the response categories that were actually recorded for each individual player. Table 5 shows the overall proportion of observed responses in each of the three categories of "Disagreeing", "Neutral" and "Agreeing" with each of Sentiments E and F, along with the overall mean of the model fitted probabilities (Model 0) for the observed responses for each player. A good model should at least be better than the naïve probabilities suggested by the observed proportions, which is clearly the case here for both sentiments. The low model predicted probabilities for the "Disagree" and "Neutral" categories, particularly with Sentiment E, are not surprising since in general, the majority of players tended to agree with these sentiments. Models 1 to 8 displayed similar levels of predictive accuracy.

Overall the assessments of model checking suggest that whilst the models are far from perfect and a great deal of variation in player's responses remains unaccounted for, the model does provide some useful value in explaining at least to some extent how players opinions relate to the explanatory variables considered.

		Disagree	Neutral	Agree
Sentiment E	Observed proportion	0.13	0.11	0.76
	Mean model probabilities	0.20	0.14	0.80
Sentiment F	Observed proportion	0.30	0.16	0.55
	Mean model probabilities	0.41	0.20	0.66

Table 5. Observed proportions for statements E and F and mean model fitted probabilities

Discussion

This paper has used a mixed effect ordinal logistic regression model to explore explanatory factors for elite players' perceptions of playing surfaces. Approximately three-quarters of players felt that all top level games should be played on Natural Turf (NT) and almost two-thirds of players felt that Artificial Turf (AT) pitches afford home teams a big advantage, yet, interestingly around a half of players agreed that they would rather play on a modern AT pitch than a poor quality NT surface. These later observations would seem to suggest that, whilst there is a general preference for NT and some variation in pitch properties is acceptable, the preference for NT may be dependent to some degree at least on the quality of that NT surface. One conclusion that can be reached from these results is that, given the option of a high-quality NT pitch, the vast majority of players would prefer to play on that surface; however, where the quality of that NT surface deteriorates there comes a point where more players (55%) would opt to use an AT pitch compared to those (29%) that would prefer to use NT regardless of its condition. Changes to surface properties have been strongly linked to football player's perceptions of overall comfort and physical performance in a small cohort of players [9] which is supported by the results of this study based on players across the globe. Further to the study by Sanchez-Sanchez *et al*. [8], the heterogeneity of playing surfaces could be viewed as beneficial for the game of the football (Figure 4) despite observed changes in physical performance.

The questionnaire enabled data to be gathered on the types of surfaces the players had experienced during their playing careers; owing to time constraints, however, it was not possible to collect data that captured the quality of the surfaces that they had experienced. Further analysis of the principal components of surface experience for each country indicated that players with the least experience on NT and greater levels of experience on gravel (i.e. low NT_{exp} and high $GRvAT_{exp}$) are typically associated with countries where the climate is less conducive to growing NT. The more apparent willingness of these players to consider alternatives to NT perhaps also reflects their experiences of particularly poor quality NT surfaces in their region, especially if they equated gravel with poor quality NT. If we assume that players' reporting greater variation in the properties of surfaces is indicative of exposure to more poor quality surfaces then this may also explain why these players are more likely to agree with sentiments supporting the use of an alternative surface. Finally, a player that considers, for example, AT to have desirable qualities such as being softer, thicker and faster than NT may be a result of having experienced a combination of good quality AT and NT that is hard, slow and with patchy grass, characteristics of NT surfaces in harsher climates. This would suggest that the quality of the surfaces players have experienced may impact on their overall opinions and that surface quality may be an underlying factor that is related to many of the explanatory variables used in the model. Zanetti [10] previously suggested that playing surface qualities such as the grass, asphalt base or compaction levels would influence a player's perception of football performance more than properties such as the type of infill.

Main Conclusions

The mixed effect model has provided insights into the factors that could explain elite football players' perceptions of playing surfaces. The majority of players expressed a strong preference for the use of Natural Turf pitches over alternatives such as Artificial Turf although

this preference is likely to be based on the assumption of a good quality Natural Turf pitch. Whilst many players reported that they consider adapting to different surfaces to be a fundamental part of the game, variation in the properties of both Natural Turf and Artificial Turf pitches actually appears to be undesirable. Use of ordinal logistic regression models enabled players' opinions to be related to a number of explanatory factors. Players with more experience of Natural Turf surfaces tended to have stronger preferences for using a traditional grass pitch, whatever its condition, compared to Artificial Turf. Those that had more experience of alternative surfaces and considered Natural Turf to have greater variability and less desirable surface properties compared to Artificial Turf, were more likely to be in favour of using an artificial surface over a poor quality Natural Turf pitch. One limitation of this study was the considerable between-country variation in opinions that could not be explained by the factors investigated in this paper. This could be due to other factors not included in the model, or could indeed potentially reflect purely cultural or other differences, or may even just be variation due to random noise but further work is required to explore these potential causes.

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FIFA Confederation	Participating Country	Number of Players			Age (Years)	
		Female	Male	Total	Mean	SD
AFC (Asia)	Australia	0	10	10	26.8	4.49
	Hong Kong	0	35	35	25.3	4.82
	India	0	32	32	24.3	6.07
	Indonesia	0	1	1	35.0	NA
	Japan	25	0	25	24.9	3.86
	Philippines	0	5	5	23.8	4.55
	Singapore	1	38	39	25.5	2.91
	Thailand	0	14	14	24.4	4.78
CAF (Africa)	Botswana	0	33	33	24.8	4.46
	Dem. Rep. of Congo	0	41	41	22.1	4.24
	Egypt	0	7	7	29.4	4.79
	Ivory Coast	0	34	34	23.3	4.32
	Morocco	0	20	20	25.2	3.59
	Namibia	0	20	20	25.9	4.42
	Zimbabwe	0	44	44	25.1	3.50
CONCACAF (North and Central America and the Caribbean)	Jamaica	0	53	53	23.5	5.19
	Mexico	0	46	46	26.7	4.52
CONMEBOL (South America)	Argentina	0	18	18	23.1	3.39
	Bolivia	0	2	2	34.0	7.07
	Brazil	0	11	11	23.8	4.51
	Chile	0	32	32	25.5	3.62
	Colombia	0	1	1	26.0	NA
	Paraguay	0	1	1	27.0	NA
	Peru	0	49	49	26.9	5.42
	Uruguay	0	1	1	36.0	NA
OFC (Oceania)	Fiji	0	12	12	24.7	3.26
	New Zealand	0	17	17	26.9	6.27
	Papua New Guinea	0	21	21	25.9	3.56
UEFA (Europe)	Bosnia & Herzegovina	0	1	1	27.0	NA
	England	37	93	130	23.5	4.34
	Estonia	0	2	2	22.0	1.41
	Finland	0	17	17	23.5	3.02
	France	17	51	68	25.8	4.63
	Germany	25	59	84	24.4	4.15
	Iceland	6	15	21	23.7	3.45
	Ireland	0	17	17	25.2	4.81
	Italy	0	1	1	33.0	NA
	Netherlands	0	8	8	28.2	4.33
	Norway	0	16	16	23.2	3.13
	Portugal	0	55	55	25.4	3.81
	Russian Federation	0	32	32	26.8	5.30
	Scotland	0	1	1	24.0	NA
	Spain	0	1	1	24.0	NA
	Sweden	0	51	51	24.8	4.66
Overall		111	1,018	1,129	24.9	4.57

Appendix