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Citation for final published version:

Strutzenberger, Gerda, Edmunds, Rob, Nokes, Len D. M., Mitchell, Ian D., Mellalieu, Stephen D. and Irwin, Gareth 2020. Player-surface interactions: perception in elite soccer and rugby players on artificial and natural turf. *Sports Biomechanics* 10.1080/14763141.2020.1720279 file

Publishers page: <http://dx.doi.org/10.1080/14763141.2020.1720279>
<<http://dx.doi.org/10.1080/14763141.2020.1720279>>

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1 **Player-surface interactions: Perception in elite soccer**
2 **and rugby players on artificial and natural turf**

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4 Gerda Strutzenberger^{a,b*}, Rob Edmunds^b,

5 Len, D. M. Nokes^c, Ian, D. Mitchell^d, Stephen, D. Mellalieu^b & Gareth Irwin^b

6 *Submission July 2018*

7 *Revision1 April 2019*

8 *Revision2 September 2019*

9
10 ^a Department of Sport Science and Kinesiology/USI, University of Salzburg, Salzburg,
11 Austria

12
13 ^b School of Sport and Health Sciences, Cardiff Metropolitan University, Cardiff, UK.

14
15 ^c School of Engineering, Cardiff University, Cardiff, UK.

16
17 ^d People and Team Development, The Football Association, Burton Upon Trent.

18
19 *corresponding author: Gerda Strutzenberger. gerda.strutzenberger@sbg.ac.at

22 **Player-surface interactions: perception in elite soccer**
23 **and rugby players on artificial and natural turf**

24 **Abstract**

25 Artificial turf (AT) is common at all levels of soccer and rugby. Employing an interdisciplinary
26 design this study aimed to examine the extent to which the negative attitude commonly
27 expressed by players concerning AT is based on difference in technique between AT and natural
28 turf (NT), or due to pre-existing biases. Thirty professional soccer and rugby players performed
29 a defined set of movements with masked and normal perception conditions on NT and AT.
30 Two-dimensional kinematic analysis (100 Hz) of characteristics in parallel to a psychological
31 assessment of the impact of cognitive bias for a playing surface was assessed. No significant
32 interaction effects between level of perception and surface type were found. For AT, contact
33 time (CT) was shorter across conditions, while for NT rugby players had longer CT during
34 acceleration/deceleration phases and shorter flight times. Pre-existing negative bias against AT
35 was found during the normal perception trials in the technology acceptance model (Usefulness
36 and Ease of Use) and the general preference questions on how much the athlete would like to
37 play a game on it. The results suggest that opinion was not driven by surface characteristics,
38 but by a cognitive bias, players brought with them to the pitch.

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40
41 *Key words:* perception; biomechanics; psychometrics; football codes; artificial turf
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44 **Introduction**

45 Replacing natural (NT) with artificial turf (AT) provides a durable, flexible and cost effective
46 option, which can offer usable playing surfaces across the globe. Significant improvements in
47 the quality of AT from first generation to current third generation (3G) emerged from two
48 perspectives, firstly, materials including cushioning, different fibre polymers and infills
49 (Strutzenberger, Potthast, & Irwin, 2018b) and; secondly, player-surface interaction, addressing
50 injury occurrence (e.g. Ekstrand, Hagglund, & Fuller, 2011; Strutzenberger, Nokes, & Irwin,
51 2018a; Williams, Akogyrem, & Williams, 2013), physiological fatigue and the biomechanics
52 of cutting, turning, and kicking (Hughes et al., 2013; Strutzenberger et al., 2018b).

53 Despite the fact that players report a dislike for AT (Johansson & Nilsson, 2007) no differences
54 have been reported in physiological indices across the two surfaces (i.e., metabolic cost of
55 running (Sassi et al., 2011)), with only small differences for turning when playing on AT
56 compared to NT. Research has found that players reported a dissatisfaction with safety aspects
57 of AT, and while they felt AT was acceptable as a surface this was dependent on past experience
58 (Burillo, Gallardo, Felipe, & Gallardo, 2014). In light of the limited research to date, further
59 consideration is warranted regarding player perceptions of performing on different surfaces
60 (Hughes et al., 2013). This is particularly salient given that previous research with elite players
61 has reported a negative perception of both physiological and technical aspects of match play on
62 AT compared to NT (Andersson, Ekblom, & Krstrup, 2008; Zanetti, 2009). Additionally, as
63 player perception may be influenced by inference, memory, and knowledge representation
64 (Vickers, 2007), underpinning factors that may contribute to both the real and perceived
65 differences reported between AT and NT (Johansson & Nilsson, 2007; Potthast, Verhelst,
66 Hughes, Stone, & De Clercq, 2010; Poulos et al., 2014; Roberts, Osei-Owusu, Harland, Owen,
67 & Smith, 2014; Ronkainen, Osei-Owusu, Webster, Harland, & Roberts, 2012; Young, 2007)
68 need to be considered. Player acceptance of the surface is central to turf development and the

69 introduction of AT within and across team-based sports, a desire that has been publicly
70 communicated by the international governing body of soccer (FIFA, Quality Report). In
71 addition to soccer, artificial surfaces are also being used at the highest level of rugby union in
72 both training and competition. Insights from examining perceptions of performers and
73 contrasting them across the respective codes of football (soccer and rugby union) would be
74 desirable. The current research aims were to examine professional athletes' movement
75 characteristics when playing on NT and AT and their perceptions of playing on these surfaces,
76 while controlling for any bias of opinion. The following hypotheses were proposed: First,
77 biomechanics of technique during a sport-specific manoeuvre differs between NT and AT,
78 when players are aware of the surface type. Second, players perceive the playing surface
79 differently, when they are aware of the surface type and third, perceptions and biomechanics of
80 technical performance differ across codes of football.

81 **Methods**

82 An interdisciplinary cross-sectional design was used to examine the impact of playing surface
83 type on a defined set of sport-specific movements and the players' perceptions of the turf.
84 Fifteen elite professional soccer players (age: 18.4 ± 1.2 years, height: 1.80 ± 0.04 m, mass:
85 74.7 ± 5.4 kg) and 15 elite rugby players (age: 18.8 ± 1.1 years, height: 1.81 ± 0.07 cm, mass:
86 94.6 ± 13.2 kg) performed a warm-up and familiarisation on a neutral NT surface in both
87 masked and normal perception condition. Following this, athletes completed four repetitions of
88 a sport-specific movement task (Figure 1b) on a NT and a third generation (3G) AT surface and
89 answered a player perceptions questionnaire. Institutional ethics approval of the Cardiff
90 Metropolitan University, Cardiff School of Sport and Health Sciences Ethics Committee was granted
91 and informed consent obtained. The movement task comprised a 10 step accelerated run to
92 maximum velocity, a 180° turn, a 6 step accelerated run followed by a cut (Figure 1b). The task

93 was performed four times each in masked (M) (visual - blindfolds, auditory - ear plugs and
94 olfactory - nose clips) and normal (N) perception conditions on both NT and AT in randomised
95 order.

96 ---Inset Figure 1 ---

97 After each test setting, participants were transported to a survey room, where perception was
98 returned to normal and athletes were asked to complete a questionnaire. When completed,
99 players were transported to the next surface. During the masked conditions athletes were
100 transported via a random course to disorient them so they remained unaware of the surface used
101 for testing. The procedure was repeated for subsequent trials.

102 All data were collected at a national rugby and soccer training centre, the 3G AT pitch used was
103 a FIFA 2* quality and a World Rugby Union approved pitch and is used by both codes of sports.

104 A separate soccer and rugby NT was used for data collections, approved for quality by their
105 respective codes. Prior to each testing session, each surface was measured for hardness with a
106 Clegg Impact Soil Tester Type CIST/883/Stor/Blu (2.25kg). To exclude very hard (dry) and
107 very soft (wet) surface conditions due to the weather on individual testing days, testing was
108 only undertaken when the Clegg Impact Value (CIV) was between 55 – 90 CIV. The soccer
109 NT hardness ranged between 59.3 - 72.3 (CIV), the rugby NT ranged between 81.1 - 82.7 CIV
110 and the 3G AT pitch ranged between 80.8 - 85.5 CIV.

111 For the biomechanical data collections the movement task was recorded with two high speed
112 cameras (2 x acA2000-50gc, Basler AG, 100 Hz, Ahrensburg, Germany) using Templo
113 software (v. 7.0.292, Contemplas GmbH, Kempten, Germany). Each camera collected data of
114 10 m (2000 x 480 pixels on each camera) of the initial and final accelerated sprint, turn and cut
115 (Figure 1c). These tasks were selected to fulfil the requirements a) high relevance for each code
116 of sport and b) be able to be detected by a 2D-video analysis by being performed in one plane
117 of action. The set-up of the movement task allowed for the velocity, the step lengths, the contact

118 and flight times and the absolute distance to each step from acceleration task, the distance to
119 when the turn occurred and the contact time of the cutting foot could be analysed. Data from
120 seven soccer players had to be excluded from biomechanical analysis, as these participants
121 moved outside of the desired movement path for 2D-video analysis in masked condition. For
122 the biomechanical analysis in detail the videos were transferred into Vicon Motus 10.0 (Vicon
123 Motion System, Inc., Oxford, UK) software for manual digitising. For each foot strike (FS), the
124 first frame where the foot contacted the ground and for each foot off (FO), the first frame where
125 the foot has left the ground was defined as foot strike (FS) and foot off (FO) event to identify
126 contact time [s] (acceleration task and cut), flight time [s], step frequency ($1 / (\text{contact time} +$
127 $\text{flight time})$) [1/s] and absolute time between the start and each FS [s]. Additionally, the position
128 of the toe (identified via the tip of the shoe) as well as the trochanter position (visual assessment)
129 was digitised, to identify step length (distance the toe marker travelled between FS events) [m],
130 distance covered with each step until the turn (trochanter position) [m], and velocity at each FS
131 ($\text{distance}/\text{time}$ of each FS) [m/s]. For each condition the trial with the fastest velocity at step 5
132 was used for further analysis. Even though participants were rehearsed to accelerate 10 steps,
133 not all did in the given set of four testing trials (12 ± 1 steps (N) 12 ± 2 steps (M)). Therefore, data
134 for the acceleration phase were calculated until contact 8, as this was the minimum number of
135 contacts taken by a participant before entering the turn. The parameter for the turn was the
136 contact phase of the foot that realised the turn to the full 180° .

137 The psychological analysis aimed to identify the player's perceptions of the surface via a multi-
138 dimensional psychometric instrument, consisting of the four main scales: a) physical effort; b)
139 manoeuvre perception; c) Technology-Acceptance-Model (TAM) (Davis, 1989); and d)
140 Pleasure-Arousal-Dominance, PAD (Mehrabian, 1996). The physical effort scale (a) comprised
141 of a visual-analogue scale (Andersson et al., 2008). Players were asked how hard the trials were
142 in general, which effort they made during the trials, how hard the trials were physically at that

143 day and how tired they were. The manoeuvre perception items (b) were used to triangulate with
144 the biomechanics measures. A six item scale interrogated perception of the soccer-specific
145 movement task via five-point rating scales. Players were asked if the surface hindered
146 manoeuvres supported their acceleration and deceleration, supported the cutting manoeuvre,
147 produced good force generation and good grip. The TAM (Davis, 1989) (c) was utilised to
148 understand the acceptance of AT and NT from a perceived usability perspective. Participants
149 were asked to rate on a five point scale the perceived 'Usefulness' and 'Ease of Use' of the
150 surface just performed on. Finally, the PAD (Mehrabian, 1996) scale (d) was used to assess
151 players' affective responses to the surface, as it measures the underlying dimensions of pleasure
152 (valence), arousal (anxiety) and dominance (control). Participants were asked to indicate on a
153 five point scale the extent to which they are experiencing pleasure-displeasure, arousal-
154 nonarousal and dominance-submissiveness. Additionally, general perception (e) was asked as
155 a validity check via the two overarching questions: A) if players would 'like to play an
156 important match on the surface' and B) 'how other players would like to play on it'. Last,
157 athletes were asked whether they realised the surface type they just performed on including a
158 confidence rating of this guess (questionnaire; a complete copy of the questionnaire used is
159 available from the corresponding author). For the psychometric analysis the subscales scores
160 for each item were identified.

161 Statistics were calculated using SPSS (version 17.0, IBM, Armonk, NY, USA). All variables
162 met normality via the Kolmogorov-Smirnov test. For the biomechanical data the effect of the
163 factor code of football (Soccer vs. Rugby – between participants) was identified in a first step
164 via a three-factorial (Perception (M, N) – within participants) x (Surface (AT, NT) – within
165 participants) x code of football (Soccer, Rugby) - between participants) multivariate (steps 0 –
166 8) ANOVA. For parameters showing a difference between codes of football the following
167 analysis was performed for the participants of each football code separately to overcome the

168 delimitation of using their specific natural turfs, otherwise all participants were pooled together.
169 As such both, the biomechanical and questionnaire data were subjected to a 2 x 2 ANOVA,
170 (Perception (M, N)) x Surface (AT, NT) with the dependent measures being the steps
171 (biomechanics) and the subscale scores (psychology). A Bonferroni correction was used and
172 statistical significance was set to $p=0.05$. Effect sizes were calculated via partial eta squared
173 (η_p^2 ; small >0.01 , medium >0.05 , large >0.14 (Cohen, 1973). For the questionnaire data, to
174 guard against Type 1 errors arising from multiple comparisons, a doubly-multivariate test was
175 completed, to include the within-participants factors and all the scale scores. The main effects
176 and interactions that reached significance in this overall test were then used to guide in-depth
177 analysis of each sub-scale.

178 **Results**

179 With respect to the first hypothesis, biomechanical parameters showing a significant perception
180 or surface effect are displayed in Figure 2. Masking perception led on both surfaces to a
181 significantly decreased velocity (by 0.12 ± 0.01 m/s per step, averaged over all steps) in the
182 acceleration phase, shorter step lengths (by 8 ± 10 cm), absolute distance between start to each
183 step (by 18 ± 18 cm per step) and absolute distance at which the turn was executed (by $1.03 \pm$
184 0.48 m). For the cut masking perception lead to a significantly longer contact time (Figure 2).
185 Comparing AT and NT lead to a significant surface effect only for the flight time, which was
186 significantly decreased on NT for all participants and step contact times, which were
187 significantly shorter by 0.014 ± 0.004 s on AT for rugby players only. Interestingly, no analysed
188 parameter showed an interaction effect between the perception and surface. This indicates that
189 while the performance was different in masked condition, these differences occurred in equal
190 values when performing on NT as well as AT.

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---- Figure 2 -----

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With respect to the second hypothesis, analysis of the psychometric data revealed: a) physical effort: Out of the four questions only the item ‘How tired are you at the moment?’ revealed a significant perception effect (Figure 3a); b) manoeuver perception: For the six manoeuver specific questionnaire items, the analysis revealed a significant difference (surface effect) for the single item ‘How well do you think the surface supported you in deceleration?’. Players favoured the NT surface compared to the AT across both perception conditions (Figure 3b); c) TAM: Statistical analysis of the mean scores for ‘Usefulness’ and ‘Ease of Use’ found besides a significant main effect of perception (Usefulness) and surface (Usefulness and Ease of Use) a significant interaction effect between perception x surface for both scales. This suggests that during masked conditions NT and AT were perceived as similarly useful and easy to use, whereas for normal perception conditions athletes perceived the NT as significantly more useful and easy to use than the AT (Figure 3c). d) PAD: Significant perception effects for PAD indicated players found normal perception more pleasurable and enabled better control. Additionally, a significant surface effect occurred only for the pleasure sub-scale, again favouring NT over AT. It has to be noted, that the perception x surface interaction approximated significance level for dominance, ($p=0.052$), suggesting similar result to the TAM scale: When perception was normal athletes reported NT gave better control, but this was not apparent during masked perception (Figure 3d); e) general perception: Statistical analysis of the questions ‘How much would the player like to play an important game on the just used surface?’ and ‘How much does he think another player would like to play an important game on the just used surface?’ found a significant main perception (another player) and surface (himself & another player) effect and a perception x surface interaction for both questions, indicating similar results: While during masked conditions NT and AT were

217 similarly favoured to be played on for an important match, whereas for normal perception
218 conditions, players showed a significant preference for NT over AT (Figure 3e).
219 With respect to the third hypothesis, a significant interaction effect between code of football
220 and surface effect was detected in the TAM scales. While for masked conditions no differences
221 in the TAM of the surface existed regardless of surface type and code of football, soccer players
222 rated the AT significantly lower than rugby players when they were aware of the surface type:
223 Since higher levels of perceived Usefulness and Ease of Use indicate greater technology
224 acceptance, this suggests rugby union players are more likely to accept the AT than soccer
225 players and use it out of choice; Forty percent of the athletes realised independently of their
226 sport the surface they were on, 40% did not realize the surface they just performed on and 20%
227 were not sure (Figure 3e).

228

229 ----- Figure 3-----

230

231 **Discussion and Implications**

232 Employing an interdisciplinary design to address the issue of the introduction of artificial turf
233 to soccer and rugby this research examined elite athletes' perceptions of, and actual
234 performance on, a variety of surfaces while perception was both normal and masked.
235 Specifically, this study examined the perception of performing on AT is based on their
236 awareness of the surface and how this was influenced by football code.

237 The key finding that emerged from the questionnaire data was that professional soccer players
238 demonstrated on the investigated surfaces a pre-existing bias in favour of NT compared to AT.
239 Perception is well known to be influenced by past experience (Duncker, 1939) and knowledge
240 (Vickers, 2007, 2009). There is substantial literature, that suggests players recall a negative

241 impression of AT; there is a perception of increased injury risk, even though no evidence of an
242 actual increase in injury rate for AT exists (e.g. Williams et al., 2013). Consequently, NT is
243 generally preferred (Andersson et al., 2008; Ekstrand, Timpka, & Hagglund, 2006). This would
244 appear to be driven more by a cognitive bias than actual surface properties.

245 In general, the major observations from the biomechanical assessment found no difference
246 when performing on natural compared to the artificial surfaces, though there may be possible
247 intrinsic adaptation processes, such as e.g. leg stiffness alterations, at work (Newell, 1986).
248 Concurrently, Hughes et al. (2013) found that fatigue and physiological responses to soccer
249 activity did not differ markedly between these surface types. In the current study, variables
250 showing a difference between the surfaces were a decrease in initial acceleration phase contact
251 times (rugby players) and an increased flight time (all athletes) on AT compared to NT (Figure
252 2).

253 Across both codes of soccer and rugby union, the contact time for the cutting manoeuvre was
254 significantly shorter on AT. This may be due to a difference in ground reaction forces and the
255 need to attenuate these when performing on AT (Strutzenberger, Cao, Koussev, Potthast, &
256 Irwin, 2014). Expectedly, differences when perception was masked (Strutzenberger, Bath, Dill,
257 Potthast, & Irwin, 2014) in running performance in terms of step length, step velocity and
258 distance covered were observed. The organismic constraint of masking perception influenced
259 running characteristics, whilst the influence of surface did not (Newell, 1986).

260 Combining the biomechanical and questionnaire measures the main finding is that overall
261 performance outcomes remain constant across the investigated surfaces. Since the only apparent
262 difference by turf for the psychometric data occurred when players were aware of the surface
263 type, any perceived differences between AT and NT appears to be driven by a pre-existing
264 negative bias that could be regarded as an attribution bias (Carey, 2009; Fiske & Taylor, 1991).
265 While the elite soccer players' experiences seem to have resulted in a negative mind-set toward

266 AT, the elite rugby union players were more amenable to the surface and in some cases
267 preferred this playing medium. This may be explained through the use of AT at the highest
268 level of the sport in rugby union for both training and competition, whereas in male soccer this
269 is not the case. Hence, there is a clear need to examine the origins of this soccer bias.

270 Although a central issue seems to be an attitudinal one, another consideration is player
271 awareness of surface. With 40% of the players stating they were aware of the surface there is a
272 strong indication that internal or external factors were allowing players to detect the playing
273 surface. A post-hoc analysis for the TAM and PAD model with the factor Realisation of the
274 surface indicated, that those who correctly realised the surface favoured the NT compared to
275 the AT, while those who did not realize the surface type rated both surface types equally.
276 Surface awareness is a crucial component to this biases in the professional players attitude
277 towards AT as demonstrated by the fact that the rating between the used AT and NT in masked
278 condition was similar. As such surface development is still required to address issues not
279 attributable to this pre-existing bias.

280 The strength of this research rests with the interdisciplinary approach that examines
281 psychological and biomechanical responses. Both of which will be necessary for future research
282 to increase the understanding of why these perceptions emerge. Throughout this study a balance
283 between ecological validity, scientific rigour and logistical considerations had to be found.
284 Until now, studies such as Burillo et al. (2014) have only asked players their opinion of a named
285 surface; this method does not allow the removal of player response biases to determine the true
286 perception of a surface. The nature of this research, with the masked condition requires
287 consideration when making a direct link to the 'game of soccer/rugby'. Notably the performance
288 in masked condition was slower than in the normal condition, which may have confounded our
289 results. A further limitation of this study is the restriction to 2D video analysis and tracking
290 based on body-landmarks, which only allows for basic data analysis and some differences might

291 remain undetected by this method, hence the effect of surface type on 3D joint kinematics, joint
292 kinetics, muscle activation and ground contact forces on running as well as on other skills, such
293 as ball and team playing remains yet to investigate.

294 The direct implication of this research is that elite player perceptions of NT and well
295 maintained AT, during the manoeuvres and surfaces used in this study, are driven more by
296 preconceptions than actual differences between the surfaces.

297

298 **Conclusion**

299 Based on the biomechanical characteristics of performance and the key psychological variables
300 associated with technology acceptance it was observed that professional players' perception of
301 performing on AT was partly based on awareness of the surface and football code. The main
302 finding of this research was that whilst the overall performance outcomes remain constant
303 across the used surfaces players come to AT with a pre-existing negative bias; one that does not
304 employ when they are unaware of the surface type. Knowledge of these issues related to AT
305 need to be considered when introducing these surfaces to performances in rugby and soccer.

306

307 **Practical Implications**

- 308 • Overall performance outcomes remain mainly the same across surfaces.
- 309 • A pre-existing bias exists that influences negative player perception on artificial
310 surfaces.
- 311 • A football codes marketing and development strategy is recommended to address the
312 perception bias
- 313 • A more in depth analysis of the effects of artificial turf on joint loading is needed.

314

315

316 Acknowledgments: The authors would like to thank FIFA and World Rugby for funding this
317 research of the current study.

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396 **Figure legends**

397 Figure 1: Schematic overview over the measurement set-up: a) step definition, b) movement
398 task and c) camera set-up.

399

400 Figure 2... Mean (SD) values for the biomechanical parameters showing significant differences.

401

402 Note: AT=Artificial Turf, NT= Natural Turf, *P=significant perception effect (post-hoc
403 analysis), *S=significant surface effect (post-hoc analysis), p= p-value for main effects
404 (ANOVA), η_p^2 =partial eta of main effect.

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407 Figure 3: Mean (SD) responses for psychological-questionnaire items showing significant
408 differences

409

410 Note: AT=Artificial Turf, NT= Natural Turf, P=perception effect, S=surface effect,
411 PxS=interaction effect between perception and surface, TAM: Technology Acceptance Model,
412 PAD Pleasure-Arousal-Dominance scale, *= significant difference ($p \leq 0.05$). The 95%
413 confidence intervals were adjusted for within participants as Cousineau¹⁷

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