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Running head: *Anticipation and disguise*

## The use of patterns to disguise environmental cues during an anticipatory judgment task

Word count (exc. figures/tables): 4,788

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1 **Abstract**

2 A number of novel manipulations to the design of playing uniforms were used  
3 in order to try and disguise the intentions of penalty-takers in soccer. Skilled  
4 and less-skilled soccer goalkeepers were required to anticipate penalty-kick  
5 outcome while their opponent wore one of three different uniform designs that  
6 were intended to disguise the availability of potentially key information from  
7 the hip region. Variations of shapes/patterns were designed to conceal the  
8 actual alignment of the hips. Three occlusion points were used in the test film:  
9 -160 ms, -80 ms before, and at foot-ball contact. Skilled individuals reported  
10 higher accuracy scores than their less-skilled counterparts ( $p < 0.05$ ). There  
11 were no performance decrements for the less-skilled group across the  
12 different uniform conditions ( $p > 0.05$ ); however, the skilled group decreased  
13 their accuracy on the experimental conditions compared with the control ( $p <$   
14  $0.05$ ). Findings highlight the potential benefits of designing playing uniforms  
15 that facilitate disguise in sport.

16

17 Key Words: Perceptual-cognitive expertise; anticipation; sportswear design;  
18 disguise

19

1           In recent years there has been significant interest in identifying the  
2 processes and mechanisms underpinning successful anticipation and  
3 decision making (Causer & Williams, 2013). Most recently, there has been  
4 growing interest in how athletes can confuse an opponent by disguising their  
5 intentions (Jackson, Warren, & Abernethy, 2006) or by presenting false or  
6 non-veridical information (Smeeton & Williams, 2012; Williams, 2009). The  
7 aim of the current study was to identify skill-based differences in susceptibility  
8 to disguise, using uniform manipulations, in a soccer penalty kick.

9           The soccer penalty-kick has proved to be one of the most popular  
10 tasks for scientific investigation, mainly due to the considerable temporal  
11 constraints placed on the goalkeeper. On average, the time it takes the ball to  
12 reach the goal from initial ball contact is between 400-800ms (100-50Km/h)  
13 (Kuhn, 1988). Furthermore, Hughes and Wells (2002) found 87% of penalties  
14 to be struck at 75% of the players' maximal, so taking around 500ms. The  
15 lower limit for feedback utilization has been established to be around 250ms  
16 (Le Runigo, Benguigui, & Bardy, 2010) in simple interceptive tasks requiring  
17 minimal movement of a single effector. Therefore, in a more complex task  
18 such as saving penalty kicks, which requires whole body movement,  
19 goalkeepers, on the majority of penalties, cannot implement corrective  
20 feedback successfully and so have to try and anticipate ball direction before  
21 ball contact. Therefore, researchers have predominantly focused on  
22 identifying the visual cues emanating from the kicker, and how the goalkeeper  
23 can utilize these to maximize their chances of saving the penalty.

24           There is considerable debate in the literature as to the most effective  
25 areas to fixate gaze when attempting to anticipate a soccer penalty-kick. For a

1 goalkeeper to successfully intercept the ball they must anticipate two variables:  
2 height and side. The postural cues needed to anticipate the height of a  
3 penalty-kick may be different to the information needed to predict side.  
4 Williams and Burwitz (1993) suggested that when trying to anticipate the side  
5 the ball would be kicked, information was obtained from the angle of the penalty  
6 taker's run-up, the arc of the leg on approach to the ball, and angle of the  
7 kicking foot and hips prior to ball contact. The orientation of the hips was  
8 deemed particularly informative by participants, with these being positioned  
9 more square on to the goal if the ball is placed to the goalkeeper's right hand  
10 side (assuming a right-footed penalty-taker), whereas if the ball is intended to  
11 be placed to the left side the hips are inclined to slope away from the  
12 goalkeeper. Similarly, Williams and Davids (1998) reported that skilled  
13 defenders spent a higher proportion of time fixating on the hips when  
14 attempting to anticipate an opponent's actions in 1-on-1 dual situations in  
15 soccer when compared with less-skilled individuals. However, there are some  
16 methodological issues with these papers, given that Williams and Burwitz  
17 (1993) used verbal reports and Williams and Davids (1998) did not use a  
18 penalty-kick task.

19 Savelsbergh, Williams, van der Kamp and Ward (2002) reported that  
20 expert goalkeepers spent a higher proportion of time fixating the kicking leg and  
21 non-kicking leg rather than the hips, whereas novices spent more time fixating  
22 on the trunk, arms, and hips. In a subsequent study (Savelsbergh, van Gastel,  
23 & van Kampen, 2010), in which a group of expert goalkeepers were  
24 differentiated into successful and less successful performers, using their  
25 accuracy on the film-based anticipation test as the criterion measure, the non-

1 kicking leg was implicated as an important information source when attempting  
2 to anticipate penalty-kick direction. However, the visual search patterns  
3 employed were variable and the goalkeepers spent some time fixating up to  
4 eight separate locations across trials, averaging between 2.6 and 3.1 different  
5 locations per trial, with the relative importance of these areas fluctuating across  
6 the different temporal phases of the penalty-kick. Moreover, no differences in  
7 search behaviors were observed when comparing successful against  
8 unsuccessful trials, implying that anticipation is only partially dependent on the  
9 visual strategy employed (Savelsbergh et al., 2002).

10 Detailed kinematic analyses of penalty-kicks have shown that several  
11 variables correlate highly with ball direction approximately 150ms before ball  
12 contact, including the non-kicking foot angle, the knee angle of the kicking leg,  
13 and the speed of the kicking foot (Lopes, Jacobs, Travieso, & Araújo, 2014).  
14 Kinematic correlates of direction at ball contact include: kicking foot angle, the  
15 hip angle, and the movement direction of the kicking foot. Other kinematic  
16 analyses have also demonstrated similar results, with the angle of the kicking  
17 foot and angle of the hips being reported as reliable predictors of ball direction  
18 (Diaz, Fajen, & Phillips, 2012). These data demonstrate that the important  
19 predictive cues evolve over the movement and are all located in the lower part  
20 of the body. Given that the predictive information is evolving and different  
21 cues become available at different times there may be a need to fixate several  
22 sources of information over the movement. However, when the goalkeeper  
23 saccades from one fixation to another information processing is suppressed.  
24 Therefore, a large number of short duration fixations in visual search patterns  
25 will decrease the amount of information that is processed. Given the temporal

1 constraints of the task, this is not an efficient strategy. Piras and Vickers  
2 (2011) showed that soccer goalkeepers utilize a 'visual pivot' strategy where  
3 point of gaze is centrally located mid-way between the ball and hip region in  
4 order to enable optimal use of the fovea and parafovea. Furthermore, an  
5 analysis of the final five fixations prior to ball contact indicated that longer final  
6 fixations on the ball, head or shoulders were correlated with unsuccessful  
7 performance by the goalkeeper, whereas longer fixation durations on the hips,  
8 legs and feet were correlated with successful saves. These data show that  
9 stabilizing vision throughout the movement on a central source may enable  
10 the pick up of the relative motions or relationships between other information  
11 sources more efficiently.

12 In recent years, there has been increasing interest in how individuals  
13 can manipulate the information presented in their preparatory movements in  
14 order to try and disguise their actions or deceive an adversary. The process of  
15 disguise involves hiding the availability of information from a certain area by,  
16 for example, delaying its onset. In contrast, deception involves the  
17 presentation of misleading or false information rather than genuine cues with  
18 the aim of tricking an opponent into preparing for a different action to the one  
19 actually planned (Rowe, Horswill, Kronvall-Parkinson, Poulter, & McKenna,  
20 2009). While there have been several attempts to examine disguise and  
21 deception in other domains, such as in gambling and personal interaction  
22 (Blakemore & Frith, 2005; Frank & Ekman, 1997; Hyman, 1989), there have  
23 been very few published reports focusing on these topics in sport. This  
24 paucity of research is surprising given anecdotal reports linking deception and  
25 disguise to successful performance as well as the potential value of

1 developing training programmes that could facilitate the acquisition of these  
2 skills (Rowe et al., 2009).

3 Researchers have used manipulations involving other sport tasks  
4 where they either asked the actor to try, or not to try, and deceive the  
5 opponent (Cañal-Bruland, van der Kamp, & van Kesteren, 2010; Jackson et  
6 al., 2006) or they have altered the information presented to individuals by  
7 neutralizing or inverting the actor's movement dynamics at certain body  
8 locations (Huys, Smeeton, Hodges, Beek, & Williams, 2008; Williams, Huys,  
9 Cañal-Bruland, & Hagemann, 2009). An illustration of how whole-body  
10 kinematics may potentially be manipulated to examine deception and disguise  
11 is provided by the work of Huys and colleagues (Huys, Cañal-Bruland,  
12 Hagemann, & Williams, 2009; Huys et al., 2008). These authors presented  
13 tennis groundstrokes in stick-figure format where dynamic information from  
14 specific areas had been occluded, neutralized or exaggerated (Huys et al.,  
15 2009; Huys et al., 2008; Williams et al., 2009).

16 In soccer, Smeeton and Williams (2012) examined the role of  
17 exaggerated movement in penalty-kicks, to identify skill-based differences in  
18 susceptibility to deception. Novice and skilled soccer players predicted  
19 penalty-kick direction under three penalty taker movement conditions: non-  
20 deceptive, non-deceptive exaggerated and deceptive. In the biomechanical  
21 analysis between deceptive and non-deceptive movements, the authors found  
22 several significant differences in lower limb amplitudes, including landmarks in  
23 the hip region, especially at the -80 ms occlusion point. These data are  
24 corroborated by a recent kinematic analysis reporting the non-kicking foot and  
25 the hip angle to be affected by deceptive movement (Lopes et al., 2014). In

1 the anticipation phase of the study, individuals recorded higher response  
2 accuracy in the non-deceptive movements, compared to the deceptive  
3 movements, demonstrating that both skill levels were negatively affected by  
4 the non-veridical information. These data suggest that there is kinematic  
5 information available from the hip region, which, if manipulated, could  
6 negatively impact anticipatory judgments. This could be due to critical  
7 information being available directly from cues in the hip region, or the relative  
8 motion of other cues in relation to the hips.

9 Another manner in which access to information may be manipulated is  
10 through the use of the playing uniforms or apparel worn by individuals. There  
11 are published reports to suggest that uniform color can influence the formation  
12 of impressions and expectancies in sport (Hill & Barton, 2005) and specifically  
13 in the soccer penalty-kick (Greenlees, Eynon, & Thelwell, 2013; Greenlees,  
14 Leyland, Thelwell, & Filby, 2008). Playing uniforms may be designed which  
15 influence the manner in which athletes pick up information from the postural  
16 orientation of an opponent. The use of color, patterns, contrast, hue, color  
17 saturation, color values, shapes or size/fit may make it more difficult for  
18 performers to pick up the subtle differences in postural orientation that may  
19 discriminate two alternative actions (e.g., a penalty-kick to the right or left side  
20 of the goal), reducing the accuracy of visual estimations of anticipated player  
21 movements. Playing uniforms may be configured in order to make it more  
22 difficult to pick up information (i.e., disguise) or to provide an anticipated future  
23 movement that differs from the true orientation or actual movement (i.e.,  
24 deception). For example, Causer, McRobert and Williams (2013) have shown  
25 that manipulating uniform design can influence the response time and



1 accuracy of decision making/anticipation. In laboratory and field-based  
2 experiments stimulus intensity was manipulated to increase or decrease  
3 information pick up by sewing highly reflective sequins onto key areas of the  
4 playing uniforms. The data showed that in the high-intensity situation,  
5 performance accuracy significantly increased and response time significantly  
6 decreased, compared to the low-intensity condition. These data demonstrate  
7 the effectiveness of stimulus strength as a method of increasing the ability of  
8 performers to pick up visual cues, which may subsequently facilitate  
9 improvements in response time and accuracy. These findings highlight the  
10 practical utility of using manipulations to playing uniform design to positively  
11 influence performance in sport and other fields of activity.

12 In the current study, a film-based, temporal occlusion approach was  
13 used to identify skill-based differences in susceptibility to disguise. Skilled and  
14 less-skilled soccer goalkeepers will be required to anticipate penalty-kick  
15 outcome under three occlusion conditions (-160 ms; -80 ms; ball contact) and  
16 under three uniform manipulation conditions (control; zigzag; circle), based on  
17 research into disguise and camouflage in the animal kingdom (Hall, Cuthill,  
18 Baddeley, Shohet, & Scott-Samuel, 2013). The current research design,  
19 including the three uniform design manipulations chosen, was based on  
20 extensive pilot testing. It is predicted that the skilled individuals would  
21 demonstrate superior performance, when compared to their less-skilled  
22 counterparts, irrespective of the manipulation of uniform design (Savelsbergh,  
23 van der Kamp, Williams, & Ward, 2005; Savelsbergh et al., 2002; Williams &  
24 Burwitz, 1993). It is also hypothesized that both groups would record higher  
25 response accuracy in the later, compared to the earlier, occlusion points

1 (Smeeton & Williams, 2012). Due to the paucity of research on deceptive  
2 movement, it is unclear whether the uniform manipulations are likely to more  
3 greatly impact on the performance of skilled or less-skilled individuals. Despite  
4 evidence to suggest that skilled individuals are more inclined than their less-  
5 skilled counterparts to extract information from the hips (Williams & Burwitz,  
6 1993), there is contrary evidence to suggest that skilled athletes are less  
7 susceptible to the effects of disguise (Jackson et al., 2006).

## 8 **Methods**

### 9 Participants

10 Twenty-four male soccer goalkeepers volunteered to take part in the  
11 study. Participants were divided equally into either a skilled or less-skilled  
12 group based on playing level and experience. The skilled group consisted of  
13 12 players (mean age = 25.6, *SD* = 6.2 years) who currently played  
14 professional or semi-professional soccer and had been participating in the  
15 sport for an average of 11.2 (*SD* = 5.4) seasons. The less-skilled group  
16 included 12 players (mean age = 23.6, *SD* = 6.8 years) who had only  
17 recreational playing experience. Participants were free to withdraw from  
18 testing at any stage and approval for the study was gained via the local Ethics  
19 Committee of the lead author's institution.

### 20 Test Film

21 The test film was produced in conjunction with a professional soccer  
22 club in the UK. Four full-time, academy players were filmed from the  
23 goalkeeper's perspective taking penalty-kicks. The penalty takers were blind  
24 to the purpose of the study. The film clips were recorded using a digital video  
25 camera (Canon DM-XM2 PAL, Tokyo, Japan) positioned in the middle of the

1 goal at eye level (1.7 m). The players were asked to take the penalty-kick  
2 using the strategy that they would use in normal competition. Two of the  
3 players were right footed and two were left footed penalty takers. A regular  
4 dimension goal was used and players were required to shoot into each of the  
5 four corners of the goal in turn. If the ball finished in the middle of the goal, the  
6 trial was discarded. Each film clip included the penalty taker's approach to the  
7 ball and all his preparatory actions until the ball was kicked. Players were  
8 required to place one penalty in each corner while wearing one of three  
9 different uniform designs (i.e., 16 penalties for each uniform), providing a total  
10 of 48 penalties. The players were informed that they should imagine that they  
11 were taking a penalty in a competitive match situation. The footage was then  
12 digitally edited using Adobe Premiere Pro CS4 software (Adobe Systems  
13 Incorporated, San Jose, CA) so that each clip was temporally-occluded at  
14 either the moment of ball contact, 80 ms before ball contact (-80 ms) or 160  
15 ms before ball contact (-160 ms). An illustration of the approach is provided in  
16 Figure 1.

17

18

Insert Figure 1 here

19

20 Procedure

21 The film clips were back-projected, using a LCD video projector  
22 (Hitachi CP-X345, Yokohama, Japan) onto a 2.7 m x 3.6 m large projection  
23 screen (Draper Cinefold, Spiceland, IN). Participants stood 3.5 m away from  
24 the screen so that the film image subtended a visual angle of approximately  
25 70° in the horizontal and 55° in the vertical direction; these angles and

1 distances were used to match those of a live penalty-kick. Participants were  
2 required to verbalize the direction of the penalty kick (top left, top right, bottom  
3 left, bottom right), and also move as if there were trying to save the penalty  
4 kick. The movement was not recorded as a dependent variable, but used to  
5 increase the fidelity of the task. Participants were also required to verbalize a  
6 confidence rating of their decision after each shot (0 = not at all confident, 10  
7 = extremely confident) (Smeeton & Williams, 2012). Confidence ratings were  
8 used to determine whether the experimental uniform design effected  
9 performance through presenting deceptive or disguised information. If  
10 performance decrements were aligned to decreases in confidence ratings,  
11 this would suggest disguised information; the availability of the critical cues is  
12 compromised. Conversely, if performance decrements were aligned with high  
13 confidence ratings, this would suggest deception; the participant is using  
14 false/misleading cues (Rowe et al., 2009). No feedback was given in relation  
15 to response accuracy. A sample of six random practice trials was shown pre-  
16 experiment to help the participants familiarize themselves with the task. After  
17 familiarization, 48 film clips were presented. Shot presentation sequence was  
18 randomized across the conditions. Each trial lasted approximately 2 seconds,  
19 with 5 seconds between trials for the participant to response and reset for the  
20 next trial.

## 21 Experimental manipulations

22 The penalty takers were asked to wear three different uniform designs:  
23 control, zigzag and circle. Based on the research presented in the introduction  
24 (Piras & Vickers, 2011; Williams & Burwitz, 1993; Williams & Davids, 1998),  
25 there appears to be information available from the hip region that is critical to

1 successful anticipation of penalty-kicks. Therefore the uniforms were  
2 designed to either increase or decrease the access to important information  
3 such as: waist location, location of vertical body centerline, and hip angle.  
4 Data from biological sciences have shown that techniques such as differential  
5 blending with the background, and internal contrast between adjacent color  
6 patches can cause the appearance of false (non-object-bounding) edges (Hall  
7 et al., 2013). These effects can disrupt the continuity of a surface and make  
8 body segments and motion more difficult to detect, especially when place  
9 closer to the edge of the body (Stevens & Cuthill, 2006). The overall purpose  
10 of this is to disguise the shape and edges of an object (Thayer & Thayer,  
11 1918). With this in mind, we designed three uniforms. The control uniform  
12 consisted of a yellow shirt with black shorts; with the intention being to present  
13 a clear line or contrast between the color of the shirt and shorts so that the  
14 waistline and hip alignment are clearly demarked, making the pick-up of  
15 information from this region relatively easy. The two experimental conditions  
16 were intended to try and confuse visual attempts to precisely locate the  
17 wearer's waist or body orientation, and attenuate the effectiveness of attempts  
18 to anticipate likely subsequent motions. The zigzag uniform consisted of blue  
19 zigzags (or irregular lines/edges) across the hip area on a yellow shirt and  
20 shorts. This was to try and disguise the natural edges of the segments  
21 (Stevens & Cuthill, 2006). The circle uniform consisted of blue circles covering  
22 the hips on top of yellow shirt and shorts, the circle on the right of the uniform  
23 was higher than the circle of the left to further disrupt information pick-up. This  
24 was to provide internal contrast with false alignment (Hall et al., 2013). The  
25 different playing uniforms are presented in Figure 2.

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Insert Figure 2 here

3

4 Statistical analysis

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Response accuracy (%) was measured by comparing the participants

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response on a trial to the location the ball crossed the line. Successful

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performance was recorded when the participant correctly predicted both the

8

side and height of the penalty-kick. A percentage performance score was

9

calculated for each uniform design and occlusion point for both skill groups.

10

Confidence ratings of whether a participant's anticipatory judgment was

11

correct were recorded after each shot. Mean ratings were calculated for each

12

condition. Response accuracy and confidence ratings were analyzed using

13

separate 2 group (skilled, less-skilled) x 3 uniform (control, zigzag, circle) x 3

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occlusion point (-160 ms, -80 ms, ball contact) mixed design ANOVAs. Effect

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sizes were calculated using partial eta squared values ( $\eta_p^2$ ). Significant

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effects were followed up using pair-wise comparisons. The alpha level for

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significance was set at 0.05. The Greenhouse-Geisser correction was applied

18

when violations to sphericity were observed.

19

## Results

20

Response accuracy (%)

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There was a significant main effect for group,  $F_{1, 22} = 116.19$ ,  $p < 0.001$ ,

22

$\eta_p^2 = 0.84$ . The skilled group recorded significantly higher accuracy scores,

23

compared to the less-skilled group, see Figure 3. There was a significant main

24

effect for uniform,  $F_{2, 44} = 14.53$ ,  $p < 0.001$ ,  $\eta_p^2 = 0.40$ . Response accuracy

25

was significantly higher in the control ( $p < 0.001$ ) and circle ( $p = 0.013$ )

1 uniforms, compared to the zigzag uniform. There was a significant main effect  
2 for occlusion,  $F_{2, 44} = 62.97$ ,  $p < 0.001$ ,  $\eta_p^2 = 0.74$ . Response accuracy was  
3 significantly higher in the ball contact, compared to the -80 ms ( $p < 0.001$ ) and  
4 -160 ms ( $p < 0.001$ ) conditions. Response accuracy was also significantly  
5 higher in the -80 ms, compared to the -160 ms condition ( $p < 0.001$ ).

6 There was a significant group x uniform interaction,  $F_{2, 44} = 4.07$ ,  $p =$   
7  $0.024$ ,  $\eta_p^2 = 0.16$ . *Post hoc* testing revealed that while there were no  
8 significant differences in response accuracy between uniforms for the less-  
9 skilled group (all  $p > 0.05$ ), the skilled group decreased their response  
10 accuracy significantly from control to zigzag ( $p < 0.05$ ) and circle ( $p < 0.05$ )  
11 conditions. The response accuracy for the skilled group was also significantly  
12 higher in the circle, compared to the zigzag ( $p < 0.05$ ) condition.

13 There was a significant group x occlusion interaction,  $F_{2, 44} = 4.671$ ,  $p =$   
14  $0.014$ ,  $\eta_p^2 = 0.18$ . The less-skilled group significantly improved response  
15 accuracy from the -160 ms to -80 ms condition ( $p < 0.05$ ), and from the -80  
16 ms to the ball contact ( $p < 0.05$ ) condition. However, although the skilled  
17 group improved their response accuracy from -80 ms to ball contact ( $p <$   
18  $0.05$ ), there was no significant difference between the -160 ms and -80 ms ( $p$   
19  $> 0.05$ ) conditions. There were no significant uniform x occlusion ( $F_{4, 88} = 2.42$ ,  
20  $p = 0.055$ ,  $\eta_p^2 = 0.10$ ), or group x uniform x occlusion ( $F_{4, 88} = 1.60$ ,  $p > 0.05$ ,  
21  $\eta_p^2 = 0.07$ ) interactions.

22

23

Insert Figure 3 here

24

25 Confidence ratings

1           There was a significant main effect for group,  $F_{1, 22} = 76.13$ ,  $p < 0.001$ ,  
2  $\eta_p^2 = 0.78$ . The skilled group recorded significantly higher confidence ratings,  
3 compared to the less-skilled group, see Figure 4. There was a significant main  
4 effect for uniform,  $F_{2, 44} = 19.22$ ,  $p < 0.001$ ,  $\eta_p^2 = 0.47$ . Confidence ratings  
5 were significantly higher in the control, compared to circle ( $p = 0.019$ ) and  
6 zigzag uniform ( $p < 0.001$ ). Ratings were also significantly higher in the circle  
7 uniform, compared to the zigzag uniform ( $p = 0.014$ ). There was a significant  
8 main effect for occlusion,  $F_{2, 44} = 68.85$ ,  $p < 0.001$ ,  $\eta_p^2 = 0.76$ . Confidence  
9 ratings were significantly higher in the ball contact, compared to the -80 ms ( $p$   
10  $< 0.001$ ) and -160 ( $p < 0.001$ ) conditions. Confidence ratings were also  
11 significantly higher in the -80 ms, compared to the -160 ms condition ( $p <$   
12  $0.001$ ).

13           There was a significant group x uniform interaction,  $F_{2, 44} = 4.97$ ,  $p =$   
14  $0.011$ ,  $\eta_p^2 = 0.18$ . There were no differences in confidence ratings between  
15 the uniforms for the less-skilled participants (all  $p > 0.05$ ), whereas there was  
16 a significant decrease in confidence rating for the skilled group from the  
17 control ( $p < 0.05$ ) and circle ( $p < 0.05$ ) conditions to the zigzag condition.  
18 There was a significant group x uniform x occlusion interaction ( $F_{4, 88} = 3.07$ ,  $p$   
19  $= 0.020$ ,  $\eta_p^2 = 0.12$ ). The skilled group reported significantly higher confidence  
20 ratings in all conditions, compared to the less-skilled group, apart from the  
21 zigzag uniform at the -80 ms occlusion point. There were no significant group  
22 x occlusion ( $F_{2, 44} = 3.03$ ,  $p = 0.058$ ,  $\eta_p^2 = 0.12$ ) or uniform x occlusion ( $F_{4, 88} =$   
23  $2.37$ ,  $p = 0.056$ ,  $\eta_p^2 = 0.10$ ) interactions.

24

25

Insert Figure 4 here



1

## 2 **Discussion**

3         The aim of the current study was to identify skill-based differences in  
4 susceptibility to disguise. It was predicted that the skilled individuals would  
5 demonstrate superior performance, when compared to their less-skilled  
6 counterparts, irrespective of the manipulation of uniform design (Savelsbergh  
7 et al., 2005; Savelsbergh et al., 2002; Williams & Burwitz, 1993). It was also  
8 hypothesized that both groups would record higher response accuracy in the  
9 later, compared to the earlier, occlusion points (Smeeton & Williams, 2012).  
10 Due to the paucity of research on deceptive movement, we made no strong  
11 predictions on whether the uniform manipulations would have a greater  
12 impact on the performance of skilled or less-skilled individuals.

13         In line with previous research, the skilled individuals demonstrated  
14 significantly higher anticipation accuracy, compared to the less-skilled group,  
15 demonstrating construct validity for the test procedure. These data also  
16 support previous work (for a review see, Causer & Williams, 2013; Williams,  
17 Ward, Bell-Walker, & Ford, 2012), suggesting that skilled individuals have  
18 developed task-specific knowledge that helps them focus their attention on  
19 more pertinent areas of the display, making it easier to surmise situational  
20 probabilities from events previously experienced. These task-specific  
21 adaptations also enable the more effective processing of contextual  
22 information and experienced performers can use their superior knowledge  
23 base to dismiss highly improbable events and allocate attention to the most  
24 likely occurring events (Williams, 2009).

1           Despite the general expert advantage in anticipation, there were  
2 differences in the effects of the uniform manipulations between skill groups.  
3 The skilled group decreased their accuracy on both the circle and zigzag  
4 uniforms when compared to the control condition. This was also mirrored by  
5 the confidence rating for the skilled group, with lower confidence scores for  
6 the experimental uniforms designs. Although the response accuracy data  
7 followed a similar trend to the skilled group for the less-skilled group in the -  
8 160 and ball contact condition, there were no significant performance  
9 decrements in the experimental uniform conditions. These data suggest that  
10 the disguised uniform conditions had a negative effect on the skilled group,  
11 but not the less-skilled group. It appears that the zigzag and circle designs  
12 make it more difficult to anticipate penalty-kick outcome, presumably because  
13 they obscure the ability to pick up information from the vertical mid-line of the  
14 body and the orientation of the hips relative to the observer. There is evidence  
15 that skilled soccer players rely on information from the hip region, when  
16 making anticipation judgments (Smeeton & Williams, 2012), implying that this  
17 group would be more likely to be negatively impacted if information from this  
18 area of the body was disguised. However, it may be that the skilled individuals  
19 are fixating the hip region as a 'visual pivot', whereby they can optimize the  
20 use of the fovea and parafovea (Piras & Vickers, 2011). If this is the case, the  
21 disguised uniforms may be disrupting the relative motions or relationships  
22 between other information sources, such as the trunk and the non-kicking leg,  
23 both of which have been shown to contain information related to kicking  
24 direction and height (Williams & Burwitz, 1993; Williams & Davids, 1998).

1           The availability of information used to make anticipatory judgments  
2 changes throughout the movement. In support of our predictions and previous  
3 research (Farrow, Abernethy, & Jackson, 2005), higher accuracy for both  
4 groups was found in the later occlusion times, where players have more  
5 access to critical cues. However, the skilled group showed no difference in  
6 performance between the -160 ms and -80 ms occlusion points in the zigzag  
7 and circle conditions. These data suggest that the skilled individuals maybe  
8 trying to utilize postural information from the hip region around -80 ms before  
9 ball contact. As the information is disguised the skilled individuals cannot  
10 accurately or easily extract this information, leading to decreased  
11 performance and lower confidence ratings. These findings support work by  
12 Smeeton and Williams (2012), who found that deceptive kinematics at -80 ms  
13 before ball contact significantly reduced the anticipation accuracy of soccer  
14 players. Given that the accuracy of the skilled group dramatically increases in  
15 the ball contact occlusion point, it appears that the athletes are able to utilize  
16 other information later in the movement to accurately determine penalty-kick  
17 direction, whereas, in the -80 ms condition, they are reliant on the disguised  
18 hip information. These data may suggest that goalkeepers are able to pick up  
19 on evolving information and relevant cues as they become available (Dicks,  
20 Button, & Davids, 2010; Savelsbergh et al., 2005; Savelsbergh et al., 2010;  
21 Savelsbergh et al., 2002). It may be that if we provided non-veridical  
22 information of the non-kicking leg/foot at ball contact, then this may decrease  
23 accuracy in this condition.

24           The current dataset contradicts research that suggests that skilled  
25 athletes may be more robust to the effects of deception and disguise (Huys et

1 al., 2009; Huys et al., 2008), presumably because of their tendency to rely on  
2 more global rather than local sources of information (Jackson et al., 2006;  
3 Rowe et al., 2009; Williams et al., 2009). However, the current data suggests  
4 that the skilled individuals are still trying to use information from the hip region  
5 to make their anticipatory judgments in the deceptive uniform conditions. The  
6 fact that the decreases in performance were aligned with decreases in  
7 confidence rating for the skilled individuals shows that the deceptive uniforms  
8 did not lead to overconfidence in an incorrect anticipatory judgment, as in  
9 previous research (Smeeton & Williams, 2012). Rather, the skilled players  
10 were generally less confident about the outcome of the penalty-kick. This  
11 suggests that the experimental uniforms disguise critical information rather  
12 than provide deceptive information. Deception involves the presentation of  
13 misleading/false information rather than genuine cues with the aim of tricking  
14 an opponent into preparing for a different action to the one actually planned  
15 (Rowe et al., 2009). Instead, disguise simply makes the information more  
16 difficult to pick up, both reducing response accuracy and increasing response  
17 time. These findings corroborate previous research examining stimulus  
18 intensity of uniform designs, which showed that high-intensity uniforms enable  
19 individuals to pick up information quicker and more accurately compare to  
20 low-intensity uniforms (Causer et al., 2013). Decreasing the  
21 intensity/availability of the cues in the current study had a similar effect,  
22 leading to lower accuracy scores.

23 Findings from the current study show the potential impact uniform  
24 design can have on anticipatory judgments in temporally constrained  
25 environments. In future researchers should look to identify the specific

1 mechanisms by which anticipation is disrupted by patterns and shapes on  
2 uniforms. Despite the laboratory-based nature of this paper, the data has  
3 obvious applied implications regarding how coaches/athletes can increase the  
4 effective presentation of deceptive information. Conversely, coaches can use  
5 this knowledge to help design uniforms to increase the saliency of critical  
6 information to improve performance (Causer et al., 2013). Specifically,  
7 coaches could develop training aids that use uniform designs to highlight the  
8 important information in a particular action.

9 In summary, the current study demonstrates that although skilled  
10 athletes are better able to anticipate upcoming events based on postural  
11 cues, they are also susceptible to deceptive information, more so than less-  
12 skilled athletes. Furthermore, the data suggest that the time course of the  
13 availability of veridical and non-veridical information can be critical to the  
14 successful anticipation of upcoming actions. Our findings illustrate the  
15 practical utility of using manipulations to playing uniform design to make it  
16 harder for the perceiver to pick up the important information underpinning  
17 anticipation judgments. These data have implications for research on  
18 deception as well as coaches and athletes looking to gain an advantage over  
19 opponents.

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## References

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23 Blakemore, S. J., & Frith, C. (2005). The role of motor contagion in the  
24 prediction of action. *Neuropsychologia*, *43*(2), 260-267.

25 Cañal-Bruland, R., van der Kamp, J., & van Kesteren, J. (2010). An  
26 examination of motor and perceptual contributions to the recognition of  
27 deception from others' actions. *Human Movement Science*, *29*, 94-102.

28 Causer, J., McRobert, A. P., & Williams, A. M. (2013). The effect of stimulus  
29 intensity on response time and accuracy in dynamic, temporally-

- 1 constrained environments. *Scandinavian Journal of Medicine and*  
2 *Science in Sports*, 23, 627-634.
- 3 Causer, J., & Williams, A. M. (2013). Improving anticipation and decision  
4 making in sport. In P. O'Donoghue, J. Sampaio & T. McGarry (Eds.),  
5 *The Routledge Handbook of Sports Performance Analysis* (pp. 21-31).  
6 London: Routledge.
- 7 Diaz, G. J., Fajen, B. R., & Phillips, F. (2012). Anticipation from biological  
8 motion: the goalkeeper problem. *Journal of Experimental Psychology:*  
9 *Human Perception and Performance*, 38(4), 848.
- 10 Dicks, M., Button, C., & Davids, K. (2010). Availability of advance visual  
11 information constrains association-football goalkeeping performance  
12 during penalty kicks. *Perception*, 39, 1111-1124.
- 13 Farrow, D., Abernethy, B., & Jackson, R. C. (2005). Probing expert  
14 anticipation with the temporal occlusion paradigm: Experimental  
15 investigations of some methodological issues. *Motor Control*, 9, 332-  
16 351.
- 17 Frank, M. G., & Ekman, P. (1997). The ability to detect deceit generalizes  
18 across different types of high-stake lies. *Journal of Personality and*  
19 *Social Psychology*, 72(6), 1429-1439.
- 20 Greenlees, I., Eynon, M., & Thelwell, R. C. (2013). Color of soccer  
21 goalkeepers' uniforms influences the outcome of penalty kicks.  
22 *Perceptual and Motor Skills*, 117(1), 1-10.
- 23 Greenlees, I., Leyland, A., Thelwell, R., & Filby, W. (2008). Soccer penalty  
24 takers' uniform colour and pre-penalty kick gaze affect the impressions  
25 formed of them by opposing goalkeepers. *Journal of Sports Sciences*,  
26 26(6), 569-576.
- 27 Hall, J. R., Cuthill, I. C., Baddeley, R., Shohet, A. J., & Scott-Samuel, N. E.  
28 (2013). Camouflage, detection and identification of moving targets.  
29 *Proceedings of the Royal Society B: Biological Sciences*, 280(1758).
- 30 Hill, R. A., & Barton, R. A. (2005). Red enhances human performance in  
31 contests. *Nature*, 435, 293.
- 32 Hughes, M., & Wells, J. (2002). Analysis of penalties taken in shoot-outs.  
33 *International Journal of Performance Analysis in Sport*, 2, 55-72.
- 34 Huys, R., Cañal-Bruland, R., Hagemann, N., & Williams, A. M. (2009). The  
35 effects of occlusion, neutralization, and deception of perceptual  
36 information on anticipation in tennis. *Journal of Motor Behavior*, 41,  
37 158-171.
- 38 Huys, R., Smeeton, N. J., Hodges, N. J., Beek, P., & Williams, A. M. (2008).  
39 The dynamical information underlying anticipation skill in tennis.  
40 *Perception and Psychophysics*, 18, 1217-1234.
- 41 Hyman, R. (1989). The psychology of deception. *Annals Reviews Psychology*,  
42 40, 133-154.
- 43 Jackson, R. C., Warren, S., & Abernethy, B. (2006). Anticipation skill and  
44 susceptibility to deceptive movement. *Acta Psychologica*, 123, 355-  
45 371.
- 46 Kuhn, W. (1988). Penalty-kick strategies for shooters and goalkeepers. In T.  
47 Reilly, A. Lees, D. K & W. J. Murphy (Eds.), *Science and football* (pp.  
48 489-492). London: E & FN Spon.

- 1 Le Runigo, C., Benguigui, N., & Bardy, B. G. (2010). Visuo-motor delay,  
2 information–movement coupling, and expertise in ball sports. *Journal of*  
3 *Sports Sciences*, 28(3), 327-337.
- 4 Lopes, J. E., Jacobs, D. M., Travieso, D., & Araújo, D. (2014). Predicting the  
5 lateral direction of deceptive and non-deceptive penalty kicks in football  
6 from the kinematics of the kicker. *Human Movement Science*. 36, 199-  
7 216.
- 8 Piras, A., & Vickers, J. N. (2011). The effect of fixation transitions on quiet eye  
9 duration and performance in the soccer penalty kick: Instep versus  
10 inside kicks. *Cognitive Processing*, 12, 245-255.
- 11 Rowe, R., Horswill, M. S., Kronvall-Parkinson, M., Poulter, D. R., & McKenna,  
12 F. P. (2009). The effect of disguise on novice and expert tennis players'  
13 anticipation ability. *Journal of Applied Sport Psychology*, 21, 178-185.
- 14 Savelsbergh, G. J. P., van der Kamp, J., Williams, A. M., & Ward, P. (2005).  
15 Anticipation and visual search behaviour in expert soccer goalkeepers.  
16 *Ergonomics*, 48, 1686-1697.
- 17 Savelsbergh, G. J. P., van Gastel, P. J., & van Kampen, P. M. (2010).  
18 Anticipation of penalty kicking direction can be improved by directing  
19 attention through perceptual learning. *International Journal of Sport*  
20 *Psychology*, 41(4), 24-41.
- 21 Savelsbergh, G. J. P., Williams, A. M., van der Kamp, J., & Ward, P. (2002).  
22 Visual search, anticipation and expertise in soccer goalkeepers.  
23 *Journal of Sports Sciences*, 20, 279-287.
- 24 Smeeton, N. J., & Williams, A. M. (2012). The role of movement exaggeration  
25 in the anticipation of deceptive soccer penalty kicks. *British Journal of*  
26 *Psychology*, 3(4), 539-555.
- 27 Stevens, M., & Cuthill, I. C. (2006). Disruptive coloration, crypsis and edge  
28 detection in early visual processing. *Proceedings of the Royal Society*  
29 *B: Biological Sciences*, 273(1598), 2141-2147.
- 30 Thayer, G. H., & Thayer, A. H. (1918). *Concealing-coloration in the animal*  
31 *kingdom: an exposition of the laws of disguise through color and*  
32 *pattern*: Macmillan co.
- 33 Williams, A. M. (2009). Perceiving the intentions of others: how do skilled  
34 performers make anticipation judgments? *Progress in Brain Research*,  
35 174, 73-83.
- 36 Williams, A. M., & Burwitz, L. (1993). Advance cue utilization in soccer. In T.  
37 Reilly, J. Clarys & A. Stibbe (Eds.), *Science and Football II* (pp. 239-  
38 243). London: E & FN Spon.
- 39 Williams, A. M., & Davids, K. (1998). Visual search strategy, selective  
40 attention and expertise in soccer. *Research Quarterly for Exercise and*  
41 *Sport*, 69, 111-128.
- 42 Williams, A. M., Huys, R., Cañal-Bruland, R., & Hagemann, N. (2009). The  
43 dynamical information underpinning anticipation skill. *Human*  
44 *Movement Science*, 28, 362-370.
- 45 Williams, A. M., Ward, P., Bell-Walker, J., & Ford, P. (2012). Perceptual-  
46 cognitive expertise, practice history profiles and recall performance in  
47 soccer. *British Journal of Psychology*, 103(3), 393-411.
- 48