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Effects of availability of advance visual information on association football goalkeeping performance during penalty kicks

Matt Dicks, Chris Button & Keith Davids

Abstract

A pressing concern within the literature on anticipatory perceptual-motor behaviour is the lack of clarity on applicability of data, observed under video simulation task constraints, to natural in situ experimental conditions in which actions are coupled to perception. In the present study, we developed an in situ experimental paradigm which manipulated the duration of anticipatory visual information from a penalty taker's kinematic action to examine experienced goalkeepers' vulnerability to deception for the penalty kick in association football. Irrespective of the penalty taker's kick strategy, experienced goalkeepers initiated movement responses earlier across consecutively earlier presentation points. Overall goalkeeping performance was better in non-deception trials in comparison with deception conditions although the detrimental effect of deception subsided when information prior to the final stages of the penalty taker's kicking action was not available. It is concluded that goalkeepers are likely to benefit from avoiding anticipation of a deceptive penalty taker based on information from the run-up, in preference to later information that emerges just before the initiation of the penalty taker's kicking action.

Key words: perception and action; representative design; anticipation skill; deception

Effects of availability of advance visual information on accuracy of anticipatory perceptual-motor behaviour

1. Introduction

The ability to accurately perceive the intentions of other individuals is a skilled characteristic of many everyday interpersonal interactions. Research has shown that the perception of a person's identity (Loula, Prasad, Harber & Shiffrar, 2005) or the intention to deceive (Runeson & Frykholm, 1983) can be extracted from the movement kinematics of another individual. In this manner, skilled sports performance is believed to be founded upon an ability to accurately anticipate the intentions of significant others from their kinematic actions (for a review see, Mann, Williams, Ward, & Janelle, 2007). Eye movement studies indicate that expertise in sport is predicated on the pickup of different information between skilled and novice participants (e.g., Savelsbergh, Williams, van der Kamp & Ward, 2002), while, behavioural and brain imaging findings indicate that perceptual expertise may be reconciled by complementary motor expertise (e.g., Aglioti, Cesari, Romani, & Urgesi, 2008). Data suggest that the observation of actions that one is capable of performing activates the same *mirror* neurons in the parietal and premotor cortex that are primarily associated with movement control (Calvo-Merino, Grèzes, Glaser, Passingham, & Haggard, 2006; Rizzolatti & Craighero, 2004).

As in other everyday environments including judicial (Bond & DePaulo, 2008) and policing contexts (Vrij, 2008), sports are replete with instances in which people use deception in order to disguise their intentions (see Schorer, Baker, Fath, & Jaitner, 2007). For example, Jackson, Warren and Abernethy (2006) required rugby players to judge the running direction of an attacking player in a video simulation of a 1 vs. 1 tackle situation. Skilled participants were less susceptible to deception than novices, while there were no expertise effects for non-deception trials. The findings of Jackson et al. (2006) have been corroborated in basketball (Sebanz & Shiffrar, 2009) and handball (Cañal-Bruland & Schmidt, 2009) studies. In contrast, Rowe et al. (2009) reported that deceptive tennis ground-strokes reduced the anticipation accuracy of both expert and novice tennis players in comparison with non-deceptive strokes. However, all of these studies utilised video simulation tasks and measured participants' judgments with artificial responses (e.g., a button press), leading the respective authors to question the generalizability of their findings (see Cañal-Bruland & Schmidt, 2009, p.259-260; Jackson et al., 2006, p.368; Rowe et al., 2009, p. 185; Sebanz & Shiffrar, 2009, p.174). Such explicit recognition of the need for methodological advances in studying anticipation is harmonious with ideas on *representative design* in experimental psychology (Brunswik, 1956, for a recent review, see Dhami, Hertwig, & Hoffrage, 2004). Furthermore, Gibson's (1979) ecological approach to visual perception has heavily influenced empirical progress made in the anticipation skill literature, particularly recognising the importance of studying the reciprocal relationship between perception and action (e.g., see van der Kamp, Rivas, van Doorn, & Savelsbergh, 2008).

Central to these ideas, it has been demonstrated that the distinct functional demands of perception and action entail the pickup of different information sources when participants are required to either estimate the length (perception) or grasp (action) the shaft of a Müller-Lyer illusion presentation (van Doorn, van der Kamp, de Wit, & Savelsbergh, 2009). Such data supplement neuropsychological evidence within the framework of Milner and Goodale's (1995) two-visual-systems theory that proposes the complementary functioning of a dorsal 'vision for action' neural pathway and a ventral 'vision for perception' pathway within the cortical visual system (e.g., see Dijkerman, McIntosh, Schindler, Nijboer, & Milner, 2009; van der Kamp, Van Doorn, & Masters, 2009). Consequently, it has been noted that non-representative experimental conditions that decouple perception and action may lead to inaccurate behaviour and will not reflect the integrated function of the two-visual-systems during action (Milner & Goodale, 2008). This argument was supported by anticipation skill research utilising decoupled verbal response measures (e.g., Starkes, Edwards, Dissanayake, & Dunn, 1995) in which uncharacteristically large performance errors for skilled athletes were observed (see also van der Kamp et al., 2008).

In light of these contemporary issues in the anticipation skill literature, we developed an in situ experimental paradigm to study experienced goalkeepers' anticipation skill and susceptibility to deception for the penalty kick in association football. In our experiment, the goalkeepers could produce requisite actions and move freely to try and intercept penalty kicks in response to uninterrupted ball-flight information. The availability of visual information for goalkeepers was confined exclusively to a penalty taker's run-up and kicking action. Specifically, visual information from the penalty taker's action was added to ball-flight information across consecutive presentation points. We refer to this experimental method as the *temporal presentation paradigm*. The moments of temporal presentation were based on unfolding kinematic information during the kicking action. Research studies (see Table 1) have used a range of experimental approaches including video temporal occlusion paradigms in combination with verbal questionnaires (McMorris et al., 1993; McMorris & Colenso, 1996; Williams & Burwitz, 1993), kinematic analyses (Franks & Harvey, 1997; Williams & Griffiths, 2002) and eye movement studies (Kim & Lee, 2006; Savelsbergh et al., 2002; Savelsbergh et al., 2005) to identify candidate information sources from penalty takers' approach and kicking action. We established the distance from foot-ball contact that the respective kinematic variables were presented specific to the recruited penalty taker's kicking action.

Table 1

Summary of the commonly reported information sources presented by the penalty taker during the penalty kick run-up and kicking action

Presentation Point(s)	Information source
t5 (1452 ms) and	Angle of approach[1,3,4,8,9]
t4[7] (465ms)	Angle of hips during the approach[9]
t3 (252ms)	Trunk lean[1,4,8]
	Angle of the kicking foot and leg during the kicking phase[2,5,8]
	Angle of hip prior to contact[8]
	Non-kicking leg[5,6]
	'Visual anchor' between ball and legs[2,5]
t2 (155ms)	Non-kicking foot placement[1,6]
	Knee rotation[1]
	Kicking foot at the point of foot-ball contact[1,4]
	Hip position at ball contact[8]

Franks and Harvey (1997)[1]; Kim and Lee (2006)[2]; McMorris, et al., (1993)[3]; McMorris and Colenso (1996)[4]; Savelsbergh et al., (2002)[5]; Savelsbergh et al., (2005)[6]; van der Kamp (2006)[7]; Williams and Burwitz (1993)[8]; Williams and Griffiths (2002)[9]

Initiation of the run-up at t5 (*M* = 1564ms before foot-ball contact) reveals the angle of the penalty taker's approach (e.g., McMorris et al., 1993). Williams and Griffiths (2002) reported that penalty kicks aimed to the dominant-foot side of the goal (right side for a right-footed player), were preceded by a wide angle of approach (35°), whilst kicks to the non-dominant side (left side for a right-footed player) were approached from a narrow angle (23°). The difference in approach angle contributed to changes in hip angle which emerged around 800ms before foot-ball contact (cf. Williams & Griffiths, 2002). No additional kinematic variables have been reported to occur until initiation of the penalty taker's kicking action (i.e., kicking foot toe-off, see Nunome, Asai, Ikegami, & Sakurai, 2002). Therefore, presentation point t4 (*M* = 456ms before foot-ball contact), was utilised since previous research indicates that, on average, penalty takers' require a minimum duration of 400ms prior to foot-ball contact to alter their intended penalty kick direction (van der Kamp, 2006). It was, therefore, of interest to examine whether penalty kick execution, and thus goalkeeping performance, may be affected at this moment of the penalty taker's approach.

Information sources available after t3 (*M* = 252ms before foot-ball contact) included the arc of the kicking leg on approach to the ball, the angle of the kicking foot and hips prior to ball contact (e.g., Williams & Burwitz, 1993), and orientation of the non-kicking foot (e.g., Savelsbergh et al., 2005). Franks and Harvey (1997) reported that placement of the non-kicking foot predicted shot direction on 80% of penalty kicks taken at FIFA World Cup tournaments between 1982 and 1994. Moreover, visual search findings indicate that goalkeepers *anchor* the fovea on kicking leg, non-kicking leg and ball locations at this moment of the penalty taker's approach in order to pickup discrete biological motion information in peripheral vision (Kim & Lee, 2006; Savelsbergh et al., 2002). Gaze remains on these locations in the final moments of the kicking action after t2 (*M* = 155ms before foot-ball contact), with data further emphasising the particular importance of the non-kicking foot (see Savelsbergh et al., 2005).

Further kinematic variables revealed at t2 include the kicking foot at foot-ball contact, (e.g., McMorris et al., 1993), knee rotation of the kicking leg (Franks & Harvey, 1997) and hip position at foot-ball contact (Williams & Burwitz, 1993). When the hip is in an ‘open’ or angled position relative to the goalkeeper, then the ball is expected to go to the penalty taker’s dominant foot side of the goal, whilst a shot to the kicker’s non-dominant foot side is indicated by a square-on hip angle (cf. Williams & Burwitz, 1993). Moreover, Franks and Harvey’s (1997) analysis of World Cup performances indicated that knee rotation predicted shot direction in 98% of penalty kicks. In addition to the reported kinematic variables that have been shown to underpin horizontal kick direction, the angle of the penalty taker's trunk, which emerges at t3 is thought to indicate height of the penalty kick (e.g., McMorris et al., 1993). A penalty kick to a high goal location is characterised by the penalty taker’s trunk leaning back, while a forward lean of the trunk, in combination with head and shoulder movements over the ball, has been observed for kicks that are directed to low goal locations (cf. Williams & Burwitz, 1993).

Despite the overviewed body of literature offering understanding on candidate sources of anticipatory information, to our knowledge, no study has compared the impact of deception and non-deception penalty kick strategies on goalkeeping performance. Furthermore, research aimed at examining efficacy of perceptual training protocols and mechanisms of perceptual expertise have either instructed penalty takers to refrain from (e.g., see Poulter, Jackson, Wann, & Berry, 2005) or use deception (Savelsbergh et al., 2002; Savelsbergh et al., 2005), whilst some studies have failed to report the instructions given to the penalty taker (e.g., Williams & Burwitz, 1993). Instructing a penalty taker to use a particular kick strategy without prior understanding of the impact this is likely to have on goalkeeping performance coupled with a failure to report the instructions given to penalty takers', limits the certainty of conclusions that can be drawn across experimental studies. Therefore, in order to gain further understanding on this issue, the present study examined the effect of deception and non-deception penalty kick strategies on goalkeeping performance.

If early visual information is used to anticipate kick direction, then timing of goalkeepers' response initiation should occur earlier as visual information from the penalty taker's action is made available across consecutive presentation points. Indeed, if visual information accumulated across consecutively earlier temporal conditions benefits performance, then goalkeepers will tend to control their actions more accurately to coincide with corresponding information presentation points. Conversely, if the earlier timing of response initiation across prior temporal conditions coincides with a decrease in performance, then this outcome would indicate that the availability of early information negatively affects late information pickup. However, if late information pickup is sufficient for successful goalkeeping performance, and the availability of early information has neither a negative nor positive effect on response accuracy, then performance will remain at the same level across temporal presentation conditions.

2. Method

2. 1. Participants

Eight experienced association football goalkeepers (*M* age = 22.8 years, *SD* = 4.1) were recruited as participants with mean standing and reach heights of 1.84m (*SD* = 0.05) and 2.40m (*SD* = 0.10). Participants reported a mean of 11.63 years (*SD* = 4.4) competitive association football experience as goalkeepers and had played to at least the standard of the New Zealand Southern Premier League or equivalent. One penalty taker aged 25 years was recruited to execute all kicks. The penalty taker was appropriately matched to the goalkeepers by performance standard and length of experience, with17 years playing experience and regular experience of taking penalties in competition. The goalkeepers had no prior experience of facing penalty kicks executed by the selected penalty taker. Prior to testing and contacting participants, ethical clearance was obtained from the local University ethics committee. All players provided written consent prior to participation in the study.

2. 2. Apparatus

Penalty kicks were executed at a full-size goal area (7.32 x 2.44m) represented by a white screen (Savelsbergh et al., 2002) in an indoor Astroturf training facility. Six target sub-areas (0.81 x 1.50m) were marked on the screen as a target reference for the penalty taker (Figure 1: Savelsbergh et al., 2002). A regulation size 5 football was used with kicks taken from a distance of 11m as stipulated by Fédération Internationale de Football Association laws (FIFA, 2006).

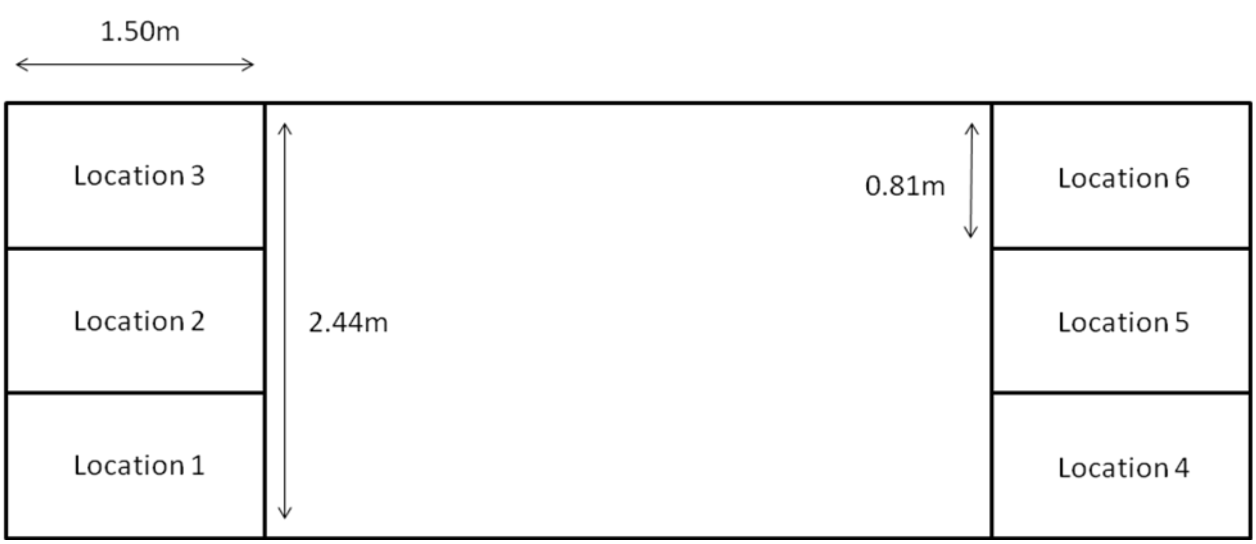

Figure 1. The goal divided into 6 locations for placement of penalties and response measures (adapted from Savelsbergh et al., 2002, p. 281).

Goalkeepers wore a pair of portable liquid-crystal apparatus for tachistoscopic occlusion (PLATO) S-2 goggles (Translucent Technologies Inc., Toronto, Ontario, Canada), which were secured by a pair of industrial earmuffs that also eliminated any auditory information from the penalty taker's approach. The PLATO goggles remained opaque prior to the initiation of the penalty taker's run-up and became translucent when the penalty taker passed through one of five timing gates (Multi-channelled sports timer). The triggering timing gate was selected by the experimenter using a dial switch prior to each trial. As the penalty taker stepped through the elected timing gate, an infrared light-beam was blocked causing the PLATO goggles to change from opaque to translucent and a super bright white light emitting diode (LED) array to illuminate. A super bright red LED array was illuminated as the penalty taker began the run-up before switching off at the point of foot-ball contact. The two LED arrays were encased within a protective box placed 1 m to the right of the goal.

Goalkeeping performance was recorded using an external, high-speed 100 Hz digital video camera (JVC GRDVL9800) placed 1.5m to the side of the penalty spot facing parallel to the goal-line. Following data capture, the goalkeepers' movement behaviours were subjected to a frame-by-frame analysis using SIMI Motion version 7 (Simi reality motion systems, Unterschleissheim). The two LED arrays were positioned in view of the video camera such that the moment the red LED dimmed represented the moment of foot-ball contact enabling the recording of a goalkeeper's action relative to this point. Ball-flight times were recorded using a pin-head microphone (Electret microphone insert, AM4011, U-62) placed beside the ball to register the moment of foot-ball contact and a second microphone, positioned next to the screen to register the point of ball impact with the goal or goalkeeper. The continuous signals of both microphones were amplified and rectified before being fed into a bipolar comparator (1000Hz). The threshold value for the bipolar comparator was set just above room noise.

2.3. Penalty kick procedure

Trials consisted of deception and non-deception penalty kicks. The penalty taker followed a test script which included instruction about which part of the goal to aim each kick toward and which kick strategy to use when facing each goalkeeper. The penalty taker had no awareness of the presentation condition being faced by the goalkeeper. For deception trials, the penalty taker was given a directive to execute the penalty as though he was intending to kick to one side of the goal, but actually to shoot at the opposite side. In non-deception trials, the penalty taker was required to shoot directly at the desired goal location without any intent to deceive.

In line with previous research (e.g., Shim, Carlton, Chow, & Chae, 2005), the penalty taker undertook five one-hour practice sessions before testing to enable him to refine his deception and non-deception strategies using recommendations derived from existing anticipation skill literature (e.g., Franks & Harvey, 1997; Nagano, Kato, & Fukuda, 2006; Williams & Griffiths, 2002). For example, during the approach to the ball the penalty taker regularly directed gaze towards (non-deception) or away from (deception) the targeted part of the goal. For penalties aimed to the dominant-foot side of the goal (right side for a right-footed player), kicks were approached from either a wide (non-deception) or narrow (deception) angle, whilst kicks to the non-dominant side were approached from a narrow (non-deception) or wide (deception) angle. For all trials, the penalty taker approached the ball from a distance of 4.0m.

2.4 Procedure

Goalkeepers were instructed on the experimental procedure and then given sufficient time to undertake a self-selected warm-up. As part of an extensive familiarization process, participants put the goggles on before each trial and oriented themselves in the same central goal location (3.66m from either post) prior to the penalty taker adopting the kick start position. Participants were instructed to wait until the goggles became translucent before initiating movement.

A *temporal presentation paradigm* was used to provide access to information at five different moments during the penalty taker's run-up. The availability of visual information for each condition occurred as the goggles switched from opaque to translucent as an infrared light-beam between two timing gates was triggered. The timing gates were located at one of five different distances relative to the ball: 4.0m before the ball position (t5), 1.6m before the ball (t4), 0.8m before the ball (t3), 0.4m before the ball (t2) and immediately behind the ball (the infrared light-beam was triggered immediately following foot-ball contact as the ball moved forward, ensuring no advance kinematic information from the penalty taker's movement was available to the goalkeepers) (t1).

The position of the timing gates was established in three stages. First, we reviewed the existing anticipation skill penalty kick literature to identify the purported kinematic variables that would be presented at the respective presentation points (see Table 1). Second, we conducted a qualitative kinematic analysis of the recruited penalty taker's kicking action in order to establish the distance from foot-ball contact that the respective kinematic variables were consistently presented during their kicking action. Finally, as all of the anticipatory kinematic variables, except those pertaining to the approach (e.g., angle of run-up), did not occur until the penalty taker's kicking action, we introduced the presentation point at t4 to partition the visual information available from the run-up (van der Kamp, 2006).

Goalkeepers faced 10 experimental familiarization trials prior to testing which consisted of both deception and non-deception kicks at each presentation point. One hundred experimental trials were presented so that there were 10 trials (five deception, five non-deception) directed to each of the two bottom corners of the goal at each presentation point. An additional 20 kicks were executed to various predetermined goal locations to remove participants' awareness of the task procedure. These trials were distributed so that there were 4 additional trials for each presentation point. Performance was not analyzed for these additional 20 trials. The order of trials was randomized and counterbalanced between participants. Testing took place over two separate sessions (each session lasted approximately 60 minutes) for each participant in order to avoid fatigue effects. Trials were blocked in six series of 20 kicks. Participants were given the opportunity to rest for a self-selected period in between each trial block.

2.5. Verification of experimental conditions

Penalty taking accuracy was checked by an experimenter after every trial. Behavioural data from kicks judged to have finished outside of the desired target location were removed from the results (this occurred for a total of 24 trials), before repeating the desired trial at a later stage in the testing protocol. Ball-flight and run-up approach times were recorded in every trial. These data were relayed to a timer via the timing gate and microphone set-up described above in the apparatus section. Data on run-up durations and ball-flight times were subjected to separate 2 (Strategy: non-deception vs. deception) x 5 (Presentation point: t5, t4, t3, t2, t1) analysis of variance (ANOVA) with repeated measures on both factors. We avoided violation of the sphericity assumption by using the Huyn-Feldt (H-F) correction procedure to adjust the degrees of freedom used for treatment and error effects (making the test more conservative). If the H-F ε estimate was below 0.75 then we reported the Greenhouse-Geisser adjustment of the *p*-value to reduce the Type I error rate (see Schutz & Gessaroli, 1987, p.134).

2.5.1. Ball-flight duration

Significant main effects for kick strategy were obtained (F(1, 7 = 8.462, p = <.05, η_p^2 = .547). Ball-flight times were slower for deception trials (M = 638ms, SE = 9.00) in comparison to non-deception trials (M = 613ms, SE = 8.00). There was no main effect for presentation point (F(4, 28 = .181, p = .946, η_p^2 = .025), and no significant interaction between strategy and presentation point (F(4, 28 = .185, p = .944, η_p^2 = .026) indicating that there were no differences for the respective ball-flight times of each kick strategy at each presentation point.

2.5.2. Run-up duration

As with ball velocity, ANOVA revealed a significant main effect for strategy (F(1, 7 = 7.716, p = <.05, η_p^2 = .524). Run-up duration increased for deception trials (M = 1464ms, SE = 8.29) in comparison with non-deception trials (M = 1440ms, SE = 8.76). For deception trials, the respective presentation points occurred at t4 = 466ms (SE = 2.47); t3 = 256ms (SE = 1.39); and t2 = 154ms (SE = 1.32) before ball contact. For non-deception trials, the presentation points occurred at t4 = 464ms (SE = 2.43); t3 = 248ms (SE = 1.25); and t2 = 145ms (SE = 1.22) before ball contact. The positioning of the timing gates ensured that t1 occurred at the point of ball contact. There was no main effect for presentation point (F(4, 28 = .432, p = .785, η_p^2 = .058), and no significant interaction between strategy and presentation point (F(4, 28 = 1.839, p = .149

η_p^2 = .208) indicating no differences for the run-up durations of each kick strategy at each presentation point.

2.6 Data analysis

The mean moment of response initiation relative to foot-ball contact was recorded to assess the extent that goalkeepers used the visual information available at each presentation point. The time of response initiation was denoted as the first observable movement made by the goalkeeper relative to the moment of foot-ball contact by the penalty taker. If the moment of initiation occurred before ball contact, a negative value was recorded. If initiation occurred after ball contact, a positive value was recorded. Trials in which the goalkeepers initiated their responses before the goggles became translucent were revealed by movement before the white LED illuminated and were subsequently excluded from further analysis. Randomly selected trials (N = 16) were re-coded by the same experimenter. Code-re-code reliability ranged between r = .99 - 1.0.

Goalkeeping performance was assessed in accordance with previous research using the mean number of penalty kicks saved. In order to gain a greater representation for any possible effects of deception, we included two additional dependent measures. First, we assessed goalkeeping performance using a categorized performance scale to provide greater sensitivity. Performance for each experimental trial was scored on a 0-5-point scale presented in Table 2 (adapted from Bennett, Button, Kingsbury, & Davids, 1999). Second, we recorded the number of response corrections (i.e., occasions where the goalkeeper moved in opposing horizontal directions) for deception and non-deception trials across each presentation point. An effective deceptive kicking action is likely to force the goalkeeper into a movement response that is opposite to the direction of the final ball location. If the initial movement response occurs early enough, then goalkeepers may still be permitted time to correct their response and dive in the direction of the final ball location.

Table 2

Description of goalkeeping behaviour in relation to the 5-point rating scale

Points scored	Description of final movement response
5	Goalkeeper successfully saves the kick, either by holding onto or blocking the ball
4	Goalkeeper dives in the correct direction and contacts the ball but fails to stop a goal from being scored
3	Goalkeeper dives in the correct direction but fails to make contact with the ball
2	Goalkeeper makes a movement in the correct direction but does not dive and fails to make contact with the ball
1	Goalkeeper does not move from the centre of the goal
0	Goalkeeper makes any final movement to the opposite side of the goal to the final ball location

The normality distribution of data sets for each of the described dependent measures were assessed using the Shapiro-Wilk test statistic *W* in combination with normality plots and separate estimates of skewness and kurtosis (Sheskin, 2004; Yan, Rodriguez, & Thomas, 2005). Post-hoc pairwise comparisons were conducted using the Bonferroni correction procedure to reduce the risk of committing Type I errors to the 5% level. Effect sizes were calculated as partial eta-squared values (η_p^2).

3. Results

3.1. *Moment of response initiation*

ANOVA revealed a significant main effect for presentation point (F(1.36, 9.53) = 134.243, p = <.001, η_p^2 = .95). No significant main effect was found for kick strategy (F(1, 7 = 0.000, p = .995, η_p^2 = .000) and there was no significant interaction between strategy and presentation point (F(3.46, 24.25 = .453, p = .669, η_p^2 = .061). Irrespective of kick strategy, goalkeepers' movement initiation was earlier as a greater duration of visual information was presented from the penalty taker's approach (see Figure 2). Goalkeepers initiated movement significantly earlier for presentation points t5 (M = -154ms, SE = 25.09) and t4 (M = -126ms, SE = 18.69) in comparison with all other conditions (all p <.001). Response initiation was significantly earlier at t3 (M = -12ms, SE = 14.97) in comparison with t2 (M = 78ms, SE = 16.05) and t1 (M = 186ms, SE = 19.10) (all p <.001), while movement initiation at t2 was significantly earlier than t1 (p <.001). There was no difference between presentation points t5 and t4 (p = 1.00).

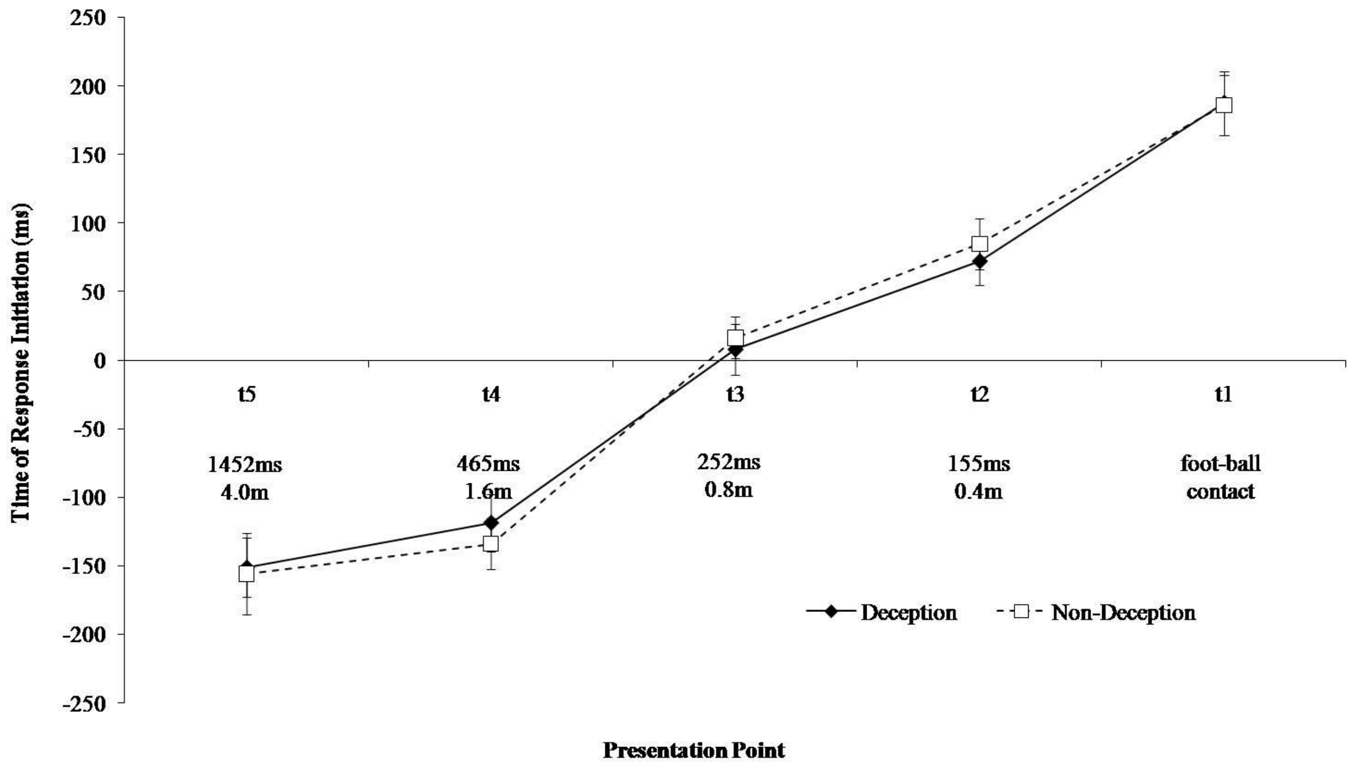

Figure 2. Mean moment of response initiation (ms) at each presentation point for deception and non-deception trials. The vertical bars indicate the standard error (SE).

3.2. Goalkeeping performance

For number of saves, ANOVA revealed significant main effects for kick strategy (F(1, 7 = 14.921, p = <.01, η_p^2 = .68), presentation point (F(4, 28 = 21.893, p = <.001, η_p^2 = .76) and a significant interaction between strategy and presentation point (F(1.456, 10.190 = 12.213, p = <.01, η_p^2 = .64). The number of saves made in non-deception trials was significantly greater than deception (p = <.01). In non-deception trials, performance was best at t5 (M = 5.13, SE = 0.35) and decreased across consecutive presentation points as the duration of information available from the penalty taker's approach reduced (see Figure 3). A different finding emerged for deception trials, with the greatest mean number of saves occurring at t3 (*M* = 1.88, SE = 0.44). Post-hoc comparisons revealed a significant difference between performance on deception trials in comparison with non-deception at t5 ($t(7) = 10.362$, $p < .001$; 95% CI for Difference = 3.18–5.07), but not at any of the other presentation points.

Further analysis of the overall mean number of saves (deception and non-deception trials) at each presentation point revealed a significant main effect for presentation point (F(4, 28 = 21.89, p = <.001, $\eta_p^2 = .76$). Bonferroni corrected post-hoc comparisons revealed that significantly more saves were made at t5 (*M* = 3.06, *SE* = 0.33) and t4 (*M* = 2.44, *SE* = 0.35) in comparison with t2 (*M* = 0.81, *SE* = 0.16) and t1 (*M* = 0.06, *SE* = 0.06) (all *p*s <.05).

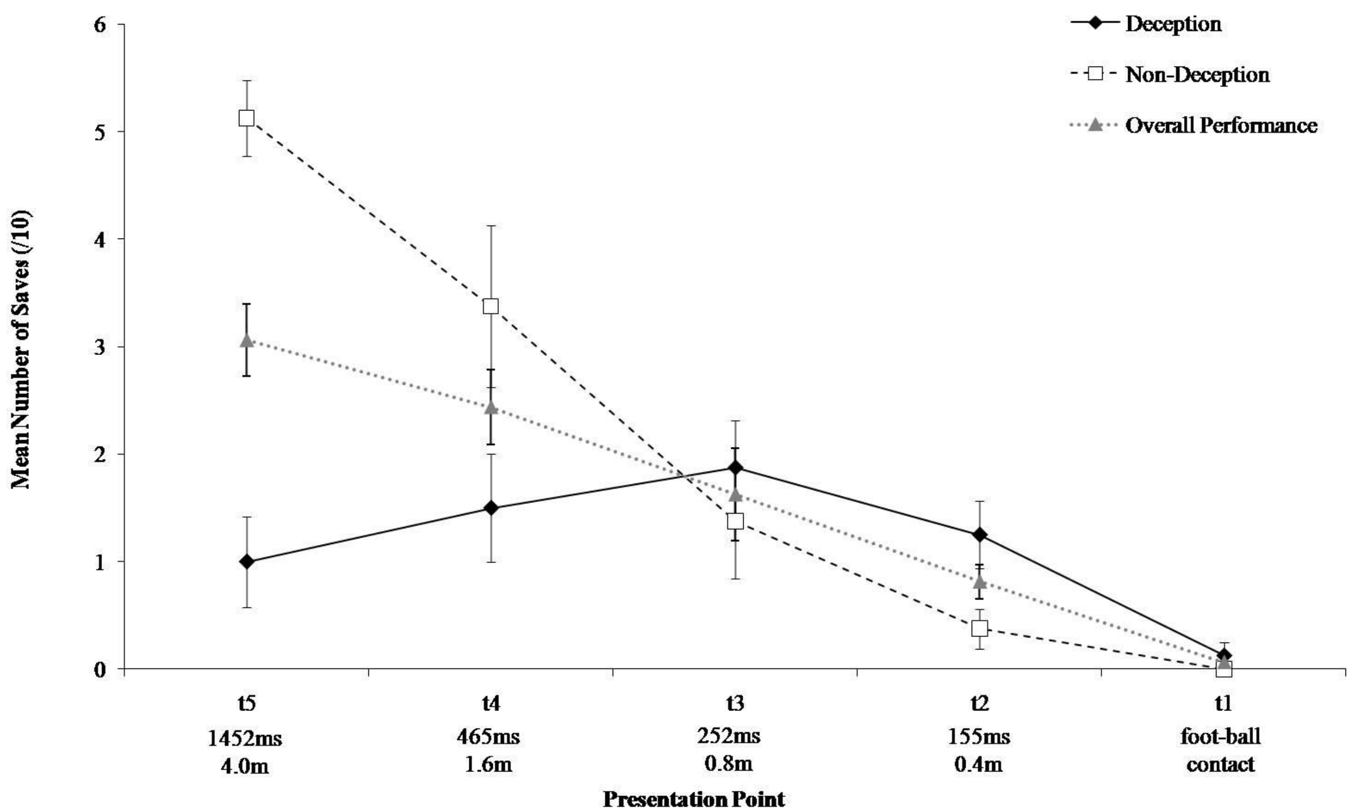

Figure 3. Mean number of penalties saved (out of 10) at each presentation point for deception, non-deception and overall performance. The vertical bars indicate the standard error (SE).

For performance on the 5-point rating scale, ANOVA results revealed significant main effects for kick strategy (*F*(1, 7 = 29.409, *p* = <.001, η_p^2 = .81), presentation point (*F*(1.667, 11.67 = 14.068, *p* = <.001, η_p^2 = .67) and a significant interaction between strategy and presentation point (*F*(4, 28 = 15.185, *p* = <.001, η_p^2 = .68). Performance for non-deception trials was significantly greater than deception trials (*p* = <.001). Consistent with the mean number of saves, performance was greatest at t5 (*M* = 4.06, SE = 0.91) for non-deception trials and t3 (*M* = 2.59, SE = 0.24) for deception trials (see Figure 4). Post-hoc comparisons revealed significant differences between deception and non-deception trials at presentation points t5 (*t*(7) = 6.934, *p* < .001; 95% CI for Difference = 1.37-2.78) and t4 (*t*(7) = 3.412, *p* < .01; 95% CI for Difference = 0.47-2.62).

Further analysis of the overall mean number of points scored (deception and non-deception trials) at each presentation point revealed a significant main effect for presentation point (*F*(1.67, 6.89 = 11.67, *p* = <.001, η_p^2 = .67). Bonferroni corrected post-hoc comparisons revealed significantly better performance across all presentation points (t5 *M* = 3.03, *SE* = 0.17; t4 *M* = 2.83, *SE* = 0.16; t3 *M* = 2.65, *SE* = 0.24; t2 *M* = 2.19, *SE* = 0.25) in comparison with t1 (*M* = 1.53, *SE* = 0.17) (all *p*s <.05).

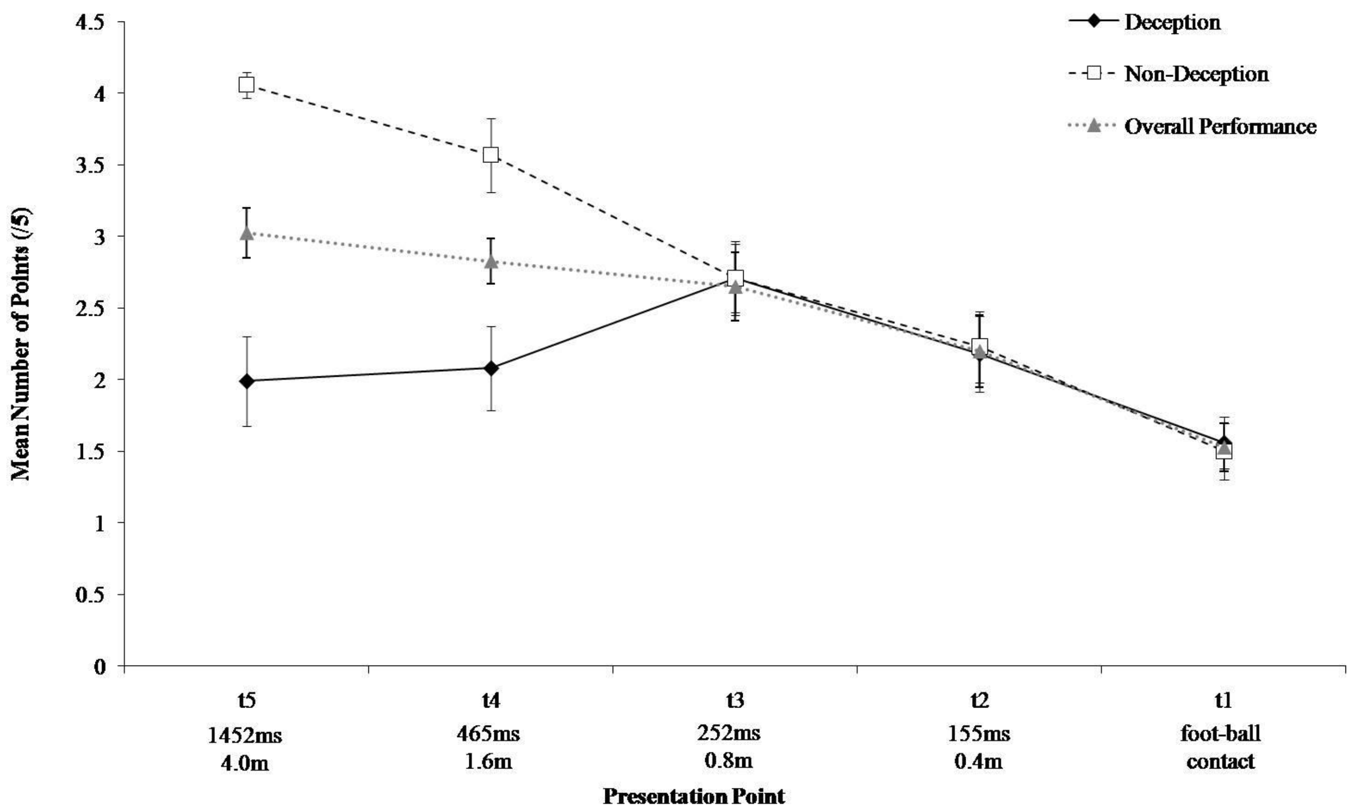

Figure 4. Mean number of points scored (out of 5) at each presentation point for deception, non-deception and overall performance. The vertical bars indicate the standard error (SE).

3.3. *Number of response corrections*

ANOVA revealed significant main effects for kick strategy (F(1, 7 = 10.272, p = <.05, η_p^2 = .59), presentation point (F(1.640, 11.477 = 9.180, p = <.01, η_p^2 = .57) and a significant interaction between strategy and presentation point (F(1.582, 11.077 = 6.677, p = <.05, η_p^2 = .48). Skilled goalkeepers made significantly more response corrections when facing deception trials in comparison with non-deception (p = <.05, Figure 5). For deception trials, the mean number of response corrections was greatest at t5 (M = 4.50, SE = 1.25). Corrections decreased slightly at t4 (M = 3.63, SE = 1.24) and further still at t3 (M = 2.00, SE = 0.60). The mean number of corrections remained < 1 at presentation point t2 and t1. In non-deception trials, the mean number of response corrections remained at < 1 for all presentation points. Post-hoc comparisons revealed that the goalkeepers made significantly more response corrections for deception trials in comparison with non-deception at t5 ($t(7) = 3.325$, $p < .05$; 95% CI for Difference = 1.23-7.27), t4 ($t(7) = 2.610$, $p < .05$; 95% CI for Difference = 0.28-5.72) and t3 ($t(7) = 2.966$, $p < .05$; 95% CI for Difference = 0.35-3.15).

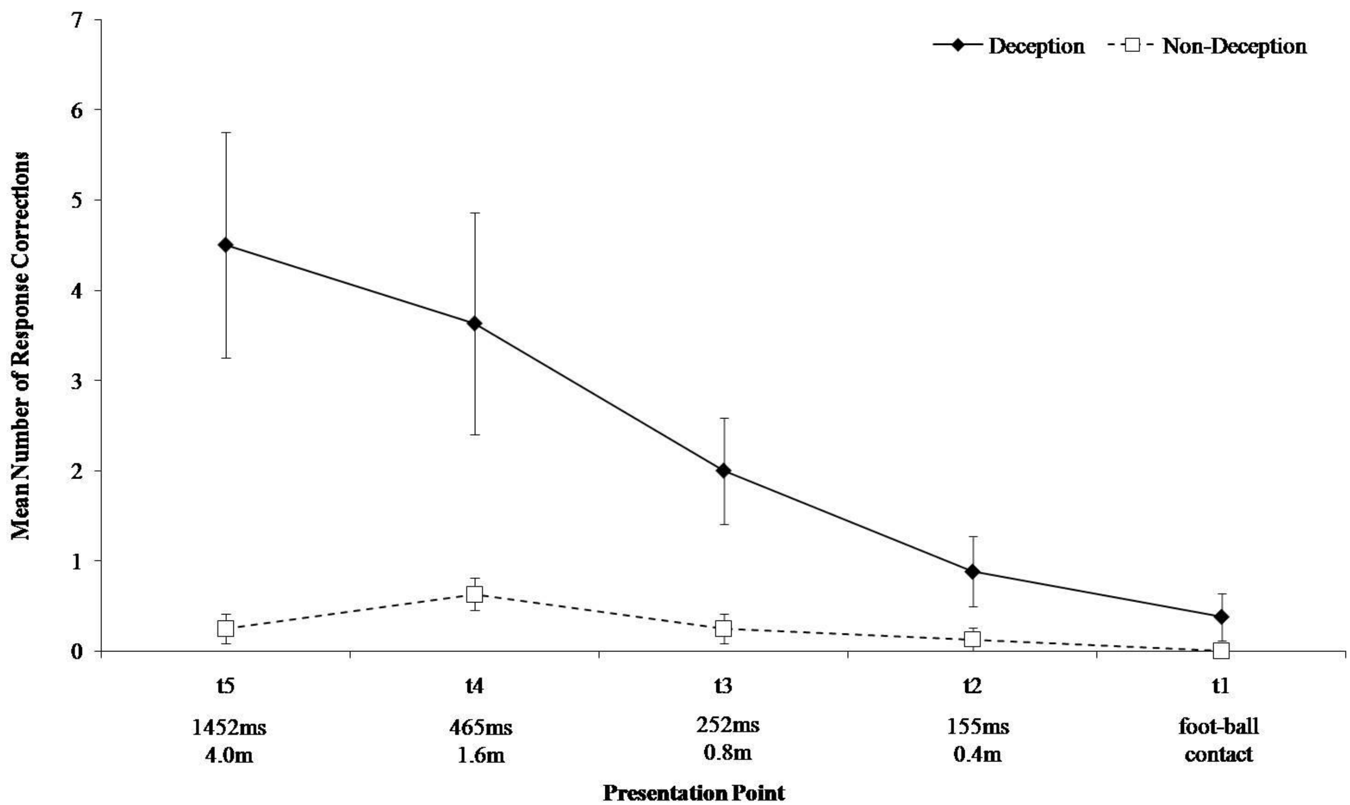

Figure 5. Mean number of response corrections (out of 10) at each presentation point for deception and non-deception trials. The vertical bars indicate the standard error (SE).

4. Discussion

An established body of existing research supports the idea that skilled sports performance is founded upon an ability to accurately judge the intentions of opponents from their kinematic actions (e.g., Jackson et al., 2006; Shim et al., 2005). However, there is mounting awareness in the anticipation skill literature concerning the generality of behavioural data observed under video simulation task constraints to in situ experimental conditions in which actions are coupled to perception. In light of the existing methodological limitations and experimental recommendations (e.g., van der Kamp et al., 2008), we developed an in situ experimental paradigm in which visual information from a penalty taker's kinematic action was added to ball-flight information across consecutive presentation points to examine experienced goalkeepers' vulnerability to deception for the penalty kick in association football.

Data revealed that, irrespective of kick strategy, goalkeepers initiated movement responses earlier across consecutive presentation points (see Figure 2). Performance accuracy was directly influenced by penalty kick strategy. Goalkeepers made more saves and scored higher on the 5-point scale for non-deception trials in comparison with deception (see Figures 3 and 4). This difference was evident despite shorter ball-flight durations in the non-deception condition in comparison with deception. For number of saves, performance was better in non-deception trials at t5 in comparison with deception, while performance was better at t5 and t4 for non-deception trials in comparison with deception on the 5-point scale. The latter finding demonstrates the benefit of introducing the 5-point scale to gain a more sensitive representation of performance. Finally, the effect of deception was further demonstrated by the finding that goalkeepers produced a greater number of response corrections at t5, t4 and t3 for deception trials in comparison with non-deception (see Figure 5).

Results of the present study support the contention that relying upon minimal advance visual information (i.e., t2 and t1) has a detrimental effect on performance due to the temporal constraints on goalkeeping performance (e.g., Franks & Harvey, 1997; McMorris et al., 1993). In addition, our findings show that if the penalty taker's intention is to deceive, then early kinematic information presented up until the penalty taker initiates their kicking action (i.e., t3: *M* = 256ms before foot-ball contact) also has a detrimental effect on the goalkeeper. In contrast, for non-deception trials, the goalkeepers' performance improved when information was available at presentation points t5 and t4. Using early information from the penalty taker's approach can be beneficial (non-deception) or detrimental (deception) to goalkeeping performance. Given this outcome, what are the practical implications of the present findings for goalkeepers when facing penalty kicks? Further analysis of the total number of saves (deception and non-deception combined) at each presentation point revealed that overall performance was better at t5 and t4 in comparison with t2 and t1 (Figure 3). This finding indicates that, overall, the availability of *early* information benefits performance. More precisely, the penalty taker's biological motion information presented from the start of the run-up (i.e., t5) does not precede more accurate goalkeeping performance in comparison with information that unfolds from 456ms before foot-ball contact (i.e., t4). Therefore, we recommend the use of training strategies that emphasise conditions in which goalkeepers learn to couple their movements to kinematic information that unfolds in the immediate moments before the penalty taker initiates their kicking action until the moment of foot-ball contact. This time-frame corresponds with penalty taker biological motions that emerge in the region of 456ms (t4) and 252ms (t3) before foot-ball contact and unfold until the penalty taker strikes the ball This strategy should offer goalkeepers' sufficient time before foot-ball contact, whilst also lessening the likelihood that they will be vulnerable to deception.

This recommendation is reconciled with the findings of Franks and Harvey (1997) who found that information sources presented earlier in the run-up (e.g., angle of approach) were incongruent with more useful, late information such as knee rotation of the kicking leg. Moreover, a trend of previous research has been to emphasise the importance of late penalty taker kinematic information including the angle of hips at foot-ball contact (Williams & Burwitz, 1993) and non-kicking foot placement (Savelsbergh et al., 2005). Penalty takers appear capable of subtly altering their biological motion in order to deceive goalkeepers during the initial portion of the run-up. However, despite any intent to deceive, it appears likely that a penalty taker's biological motion will correlate strongly with kick direction following the initiation of the kicking action. This suggestion is supported by the findings of van der Kamp (2006) who demonstrated that, on average, penalty takers require a minimum duration of 400ms prior to foot-ball contact to alter their intended penalty kick direction. It follows that, irrespective of their deceptive intention, in order to kick to a particular side of the goal, penalty takers may be required to utilise kicking actions that comprise invariant biological motion characteristics that pertain to the intended goal location (for related data of tennis players, see Huys, Smeeton, Hodges, Beek, & Williams, 2008). In order to gain a more complete understanding of the limiting kinematic constraints on action, future research is required to examine the effect of deceptive and non-deceptive penalty kick strategies on penalty takers' kick kinematics.

Schorer et al. (2007) studied the movement variability of handball players across a range of expertise levels for the penalty throw situation. Findings indicated that the most skilled player produced more variability in their movement pattern, which was interpreted to reflect the elite player's *deceptive motor expertise* (cf. Schorer et al., 2007). As demonstrated by our findings at t5 and t4 in deception trials, such behaviour reflects the intent of a performer to disguise actions.

Schorer et al.'s (2007) finding of increased movement variability with deception may also explain why a greater number of response corrections were observed for deception trials during later presentation points (Figure 5). Despite there being no overall performance differences between penalty strategies after t3, one would still expect to observe instances of deception in the penalty takers' kicking action as a function of their movement variability. Such a suggestion is supported by the study of van der Kamp (2006) who reported that penalty takers, in some instances, are still capable of successfully redirecting their kick direction with as little as 174ms before foot-ball contact. Furthermore, the expert in the study of Schorer et al. (2007) was a national team player and, therefore, had a comparatively higher level of expertise than the penalty taker in the present study and the participants in the study of van der Kamp (2006). It is, therefore, of interest to further study effects of deception across a greater continuum of skill level (e.g., Jackson et al., 2006) in order to gain a more comprehensive understanding of how experts use deception to gain an advantage over their opponents.

The likely reliability of late kinematic information from the penalty taker is further supported by the finding from video simulation studies that successful goalkeepers initiate their simulated movements closer to foot-ball contact (Savelsbergh et al., 2002; Savelsbergh et al., 2005). Furthermore, recent analysis of world-class penalty kick performances indicate that goalkeepers dive the correct way more frequently and make more saves when they deliberately wait until the moment of foot-ball contact before initiating their response (Morya, Bigatăo, Lees & Ranvaud, 2005). However, late information is largely thought to be unsuitable for successful goalkeeping performance given the temporal constraints on performance (e.g., Franks & Harvey, 1997). It would, therefore, be revealing to examine what the temporal constraints on performance offer goalkeepers relative to their individual action capabilities and bodily dimensions. That is, consideration of goalkeeping performance in response to penalty kicks is needed using Gibson's (1979) theory of affordances (for a recent overview, see Fajen, Riley & Turvey, 2009). For example, reaching heights ranged between 2.55m and 2.20m for the recruited goalkeepers' in the present study. Goalkeepers with a greater reaching height may wait until later in the penalty taker's kicking action before initiating movement as their *reachability* (e.g., Mark, Nemeth, Gardner, Dainoff, Paasche, Duffy & Grandt, 1997) may offer them the opportunity to cover a greater distance of the goal in a shorter time period. Indeed, a full account of a goalkeeper's affordances for the penalty kick would also encompass consideration of action capabilities such as movement time or jumping height (Pepping & Li, 2005).

Lastly, as with the temporal occlusion paradigm, the temporal presentation paradigm used in the present study may create an experimental finding whereby superior performance in t5 and t4 non-deception conditions is a function of the longer viewing periods rather than a consequence of the visual information available within the specific presentation periods. Farrow, Abernethy and Jackson (2005) examined this issue for tennis anticipation skill by comparing performance in response to a moving window and temporal occlusion paradigm. The moving window keeps viewing time constant while presenting the same visual information of an opponent's action in an equivalent temporal occlusion condition. Farrow et al. (2005) reported that prediction accuracy of skilled and less skilled tennis players was comparable for both the moving window and temporal occlusion conditions. Therefore, the data indicated that, it is the unfolding biological motion information at specific times which is used to control movement responses. In the present study, this effect is further indicated by the differences observed for performance in response to the deception and non-deception penalty kick strategies. An interesting avenue for future research would be to examine performance across the moving window, temporal occlusion and temporal presentation paradigms in order to gain a more complete understanding of anticipation skill.

To our knowledge, this was the first study to examine deception effects on anticipation skill under in situ experimental conditions. Goalkeeping performance for the penalty kick in association football was more accurate for non-deception trials in comparison with deception trials. However, the detrimental effect of deception on goalkeeper performance subsided following penalty taker kicking action initiation (i.e., t3: M = 256ms before foot-ball contact). Therefore, the design of learning environments in which goalkeepers couple their movements to kinematic information that unfolds in the immediate moments before the penalty taker initiates their kicking action until the moment of foot-ball contact is likely to most benefit performance. A challenge for future research is to build upon our attempts to study anticipation skill under in situ experimental task constraints that are representative of the performance environments towards which, empiricists are aiming to generalise findings (Dhami et al., 2004; van der Kamp et al., 2008).

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