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On the use of situation and body information in goalkeeper actions during a soccer penalty kick

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This study investigated the contribution of situation information about a player's preference to kick to either side of the goal on the goalkeeper's performance in a soccer penalty kick. Nine goalkeepers were tested under different situational information conditions: a non-probability, an equal-probability (i.e., 50% of the kicks to either side of the goal), and two high-probability conditions (i.e., 80% to the right or left side). In the high-probability conditions, the goalkeepers' performance tended to increase and significantly improved in terms of diving to the same side as the ball was directed. In addition, goalkeepers initiated their dive earlier in the high-probability conditions. Gaze analysis in four participants suggested that goalkeepers who relied more strongly on body information profited less from situational information. In conclusion, soccer goalkeepers can benefit from situational information about a penalty taker's preferences, but these benefits may depend on the individual goalkeeper's information-using profile.

KEY WORDS: Gaze, Interceptive actions, Perceptual anticipation, Situation probabilities, Timing.

In recent years, the soccer penalty kick has become a paradigmatic case in the study of visual anticipation for interceptive actions in highly time-constrained fast ball sports (e.g., Bakker, Oudejans, Binsch & Van der Kamp, 2006; Diaz, Fajen & Phillips, 2012; Dicks, Button & Davids, 2010a, 2010b; Dicks, Davids & Button, 2010c; Navarro, Miyamoto, Van der Kamp, Morya, Ranvaud & Savelsbergh, 2012; Noël & van der Kamp, 2012; Savelsbergh, Van der Kamp, Williams & Ward, 2005; Savelsbergh, Versloot, Masters &

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Van der Kamp, 2010; Savelsbergh, Williams, Van der Kamp & Ward, 2002; Van der Kamp, 2006, 2011; Wilson, Wood & Vine, 2009; Wood & Wilson, 2010a, 2010b). The penalty kick provides researchers a relatively controlled experimental setting to address how sports players manage to (successfully) coordinate their actions to those of their opponents. With respect to soccer goalkeeping, research has predominantly concentrated on the identification of the optical sources of information that goalkeepers exploit to guide the dive for the ball. In this respect, information from the ball's flight following the kick accurately specifies ball direction and is therefore the most accurate information source. Yet, because waiting for the ball flight information to become available significantly reduces the odds for the goalkeeper to dive in time to block the ball, the differences in goalkeepers' penalty saving skills are traditionally sought in the pick up of information from the opponents' body movements in the run-up and the actual kick of the ball, even if they are, unlike ball flight, not fully predictive with respect to the action outcome (see e.g., Franks & Harvey, 1997; Lees & Owens, 2011). Indeed, a first round of studies pointed to the differential use of (combinations of) body information that distinguished successful and less successful penalty savers among goalkeepers (Diaz et al., 2012; Franks & Harvey, 1997; Kim & Lee, 2006; McMorris & Colenso, 1996; McMorris, Copeman, Corcoran, Saunders & Potter, 1993; Savelsbergh et al., 2005; Savelsbergh et al., 2002). Typically, these studies presented pre-recorded video clips of penalty takers and required the goalkeepers to make verbal, keyboard or joystick responses in line with the perceived ball direction. By using a temporal occlusion method or measuring patterns of gaze, it was inferred that next to the initial portion of the ball flight, the movements and postures of the penalty taker's head, hips and legs contained information for anticipating ball direction. In particular, the more successful goalkeepers' superiority seemed to be based on their greater use of information from the non-kicking leg. They also waited slightly longer before responding (Franks & Harvey, 1997; Kim & Lee, 2006; Savelsbergh et al., 2005; Savelsbergh et al., 2002).

Following growing theoretical concerns over the representativeness of the design (especially with respect to the temporal occlusion method) in studies of visual anticipation in general (e.g., Van der Kamp, Rivas, Van Doorn & Savelsbergh, 2008) and the soccer penalty kick in particular (Dicks, Davids & Button, 2009; see also Lidor, Ziv & Gershon, 2012), a second round of research investigated the penalty kick *in situ* (Dicks et al., 2010b; Dicks et al., 2010c; Piras & Vickers, 2011). These studies not only underlined the advantage of more agile or faster goalkeepers who can wait longer before initiating their jump for the ball, but also strongly suggested that the more successful penalty savers rely much more on (early) ball flight information than previously considered. Thus, contrary to the lab-based studies, this work shows that *in situ* goalkeepers tend to gaze at the penalty takers head and then more or less immediately shift fixation toward the ball: the use of information from the hips and legs may actually be relatively unimportant (e.g., Dicks et al., 2010b).

Except for momentary available information from body movement and/or ball flight, the goalkeepers can also use sources of information that are less ephemeral to guide the dive for the ball, such as about a penalty taker's preference to place the ball to one side or to strike it with a certain power.[1] Thus far, however, the use of situational information[2] in penalty goalkeeping has not been assessed, and also its investigation in other fast ball sports has been largely incidental with a few exceptions. In one of the first investigations of this sort, Alain and Proteau (1980) for instance, queried skilled tennis players on the relative frequency of different strokes played by their opponent in the match they had completed a short time before. In the subsequent match analyses, Alain and Proteau (1980) found that the players anticipated (i.e., the return stroke was initiated before the opponents had completed their action) more frequently with strokes they identified as having occurred more often. This points to less reliance on ball flight and (late) body information when complementary situational information is available. In an earlier experimental study, Alain and Proteau (1978) showed that response times for events that occurred frequently (i.e., 90%) were significantly shorter than for events that occurred equally often (i.e., 50%)(see also Gray, 2002). Abernethy, Gill, Parks and Packer (2001) examined skilled squash players on court (i.e., *in situ*) using liquid crystal glasses to occlude

[1] An informal survey through e-mail among a few (former) national goalkeepers and coaches showed that the goalkeepers or their coaches keep records of penalty takers' preferences with respect to the length, speed and fluency of the run-up, and for kicking to the left, right, top and bottom corners.

[2] These sources of information are commonly referred to as *situational probabilities* and associated with knowledge structures and memory processes inside the head (e.g., Williams, 2000). From an ecological perspective (Chemero, 2009; Gibson, 1986; Withagen & Chemero, 2009; Withagen & Van der Kamp, 2010), however, information is not stored in the head, but granted by or made available in a particular situation (in this case a history of similar situations, that is, over longer periods of time). Moreover, information differs in terms of its specificity to the situation. That is, the relative frequency of prior events (e.g., kicks to the right versus kick to the left) informs about the outcome of the current situation not about a probability. Only when the past situation always resulted in the same outcome, the information is specific; otherwise the information is non-specific (or less reliable or useful). Hence, we use the term 'situational information'.

vision of the participants at different times during the opponent's strokes. They observed not only that unlike the less skilled players, elite players were able to use body information, but also that when the glasses shut early, i.e., before the opponents initiated their strokes, the elite players were still able to anticipate the direction of the stroke above chance level. The authors argued that this anticipation was granted by information that had evolved from the elite players' prior encounters with those situations. More recent research confirms this observation: repetitive encounters with an event can provide situational information that allows for more accurate anticipation than when exploiting body information alone (Crognier & Féry, 2005; Gray, 2002; McRobert, Ward, Eccles & Williams, 2011). Intriguingly, cricket batters also showed reduced gaze fixation durations when situational information from the same bowler was available, suggesting that in these situations they relied less on body information (McRobert et al., 2011).

In sum, previous research did show that skilled athletes in fast ball sports exploit, and benefit from, situational information to anticipate the opponent's actions. Yet, it did not provide full answers to the many issues that its use raises. Most importantly, is the use of situational and body (and/or ball flight) information complementary, or does the use of situational information replace or, conversely, strengthens the use of body information? Does the use of situational information merely enhance the spatial accuracy of the interceptive action, or does it also affect the timing of the action? Finally, does the use of situational information affect the spatio-temporal patterns of gaze? To shed more light on these issues, the present study examines the effects of providing goalkeepers with situational information about a penalty takers' preferences for kicking the ball to one or the other side of the goal. We do this by trying to bring together the strengths in the designs of previous work. Hence, in different conditions, the degree of specificity of the situational information was varied. Unlike previous work that manipulated situational information (Crognier & Féry, 2005; Gray, 2002; McRobert et al., 2011), the goalkeepers were required to actually save a penalty kick *in situ* (Abernethy et al., 2001; see also Dicks et al., 2010b; Dicks et al., 2010c), rather than mimicking the interceptive action or providing verbal responses. Performance accuracy (i.e., the number of saves and correct side anticipations) and timing of the interceptive action were measured, under the hypothesis that the situational information would enhance saving performance accuracy, and would allow for an earlier action (i.e., rather than waiting for the late arising and probably more specific body movement information). Finally, we attempted to measure gaze patterns (McRobert et al., 2011, see also Jovancevic-Misic & Hayhoe, 2009) in order to evaluate whether or not situational information indeed led to a shift in visual attention directed to the different sources of information (e.g., situational information may induce an earlier shift away from body information toward ball flight information).

Method

Participants

Nine male association football goalkeepers (*M* age = 24.0 years old, *SD* = 4.5) with an average of 15.0 years (*SD* = 6.1) of competitive experience as goalkeepers volunteered to participate in the study. Participants played in the first to third division teams of Dutch amateur leagues. Eighteen field players matched to the goalkeepers' level were recruited as penalty takers (*M* age = 22.0 years old, *SD* = 1.8) with an average of 14.2 (*SD* = 2.5) years of experience. Prior to testing participants provided written informed consent. the local institution's ethics review committee approved the study.

Apparatus

The penalty kicks were taken on a soccer field. The size of the goal (7.32 by 2.44 m) and the distance of the penalty mark to the goal line (11 m) were in accordance with the FIFA laws (1997), and an official 'FIFA-approved' ball was used. The actions of the goalkeepers were recorded with a digital camera (Creative Vado, HD, 30 Hz) that was placed 1.5 m behind and to the side of the penalty mark. This camera perspective also allowed us to determine the moment of foot-ball contact.

The goalkeepers' gaze patterns were recorded using a mobile eye-tracking system (Mobile Eye, ASL, Bedford, MA). The Mobile Eye is a head-mounted monocular eye-tracking system that monitors the location within the scene at which the participant is looking. An eye camera registers the participants' right eye, the x, y coordinates of the corneal reflection, and the centre of the pupil of the eye. The relative position of these features is used to compute eye line of gaze with respect to nine references within the scene. A second camera monitors the scene. The Mobile Eye system obtains the visual point of gaze (POG) by superimposing the images of both cameras with an accuracy of ±1° of visual angle and a precision of 0.5° recorded at 30 Hz using a digital videocassette recorder (DVCR; Sony GV-D1000E). The DVCR was attached to the goalkeeper's back in a padded tight-fitting back-bag in order to minimize damage to the apparatus and risk of injury to participants. In addition, participants wore a shock resistant facemask (i.e., a modified version of a regular field hockey goalkeeper's mask) to protect the Mobile Eye cameras from a ball hit. After a short period of familiarization, participants reported neither discomfort nor hindrance compared to normal performance. The eye-tracking system was calibrated by verifying that the eye-camera properly captured the eye, followed by an instruction procedure to look at pre-determined locations in the goalmouth (like the common 9-point grid). Pilot testing showed an increased risk of compromising the accuracy of calibration because of the goalkeepers' diving actions. Hence, like in previous in situ goalkeeping studies (e.g., Dicks et al., 2010b), calibration accuracy was checked after every 4 trials. Moreover, additional calibration checks were carried out when the participant reported that the eye-tracker system had moved or at any moment during testing that the experimenters considered a re-check necessary. In the case that the calibration appeared to have drifted within the 4 trials, the Mobile Eye "shift calibration" function permitted a uniform adjustment of the gaze during offline analysis.

Procedure and design

Data collection was carried out at the home pitch of the participating goalkeepers. After a self-selected warm up, and the mounting and calibration of the eye-tracking equipment, the participants performed five familiarization trials. Then, they faced four series of twelve penalty kicks, each series representing a separate experimental condition. The participants were instructed to try to stop as many penalty kicks as possible. They rested after every fourth kicks, when eye-tracker calibration was checked. The four conditions varied in the probability that penalty was kicked to the right or left side of the goal, and whether or not the participants were informed about this probabilistic distribution. Hence, in the non-probability condition, it was equally probable that the kicks were directed to right and left side of the goal, but the participants were not informed about the probabilistic distribution. In the equal-probability condition, participants were told that there was an equal probability of kicks being directed to right or left side of the goal. In the two high-probability conditions, the participants were either informed that there was an 80% probability of kicks being directed to the right side of the goal (i.e., 80r/20l) or an 80% chance that the kicks were being directed to the left side of the goal (i.e., 20r/80l). The actual distribution of kicks was determined through the use of a Matlab-algorithm that sampled the distribution at hand with replacement. Hence, the actual distribution was not identical to the pre-defined probabilistic distribution. The order of conditions was counterbalanced with the restriction that the non-probability condition always came first.

Each goalkeeper faced two players that took the penalty kicks. The penalty takers were instructed to perform the penalty kick as they would normally do, but to start the run-up from at least 3.5 m behind the ball (Van der Kamp, 2006). Before each kick, they were instructed to which side of the goal to place the ball. In the case that the ball missed the goal or was directed to the wrong side, the trial was repeated at the end of the series. Each of two penalty takers performed in two conditions only (i.e., always the non- or equal-probability and one of two high-probability conditions), and never for two conditions in a row.

Data analysis

The goalkeepers' performance was assessed off-line from the video recordings. Three dependent measures were defined: percentage of saved kicks, the performance scores based on 5-point scale, and percentage of dives to the correct side. The performance score was taken from Dicks et al. (2010a): 5 points were assigned when the penalty was saved, 4 points when the goalkeeper contacted the ball but failed to save, 3 points when the goalkeeper dived to the correct side, 2 points for a move to the correct side, but without a dive, 1 point when not moving from the centre of the goal, and 0 points were awarded when the goalkeeper missed the ball and moved to the incorrect side. Further, movement onset was used to assess the timing of the save, and was defined as the instant that the first observable leg movement was made by the goalkeeper's leg relative to the moment of foot-ball contact (Sánchez, Sicilia, Guerrero &

Pugnaire, 2005). Negative signed values denote initiation before ball contact. The dependent variables were submitted to separate ANOVAs with repeated measures on condition (non-probability, equal-probability, high-probability to the right (i.e., 80r/20l), high-probability to the left (i.e., 20r/80l). Post hoc comparisons were carried out using Bonferroni t-tests.

Participants' gaze patterns were analysed frame by frame (30 Hz), starting in the run-up from 1000 ms prior to foot-ball contact, until 100 ms after the start of the ball flight. Following Van der Kamp (2011), we determined the percentages of viewing time for different relevant regions using all sampled frames rather than only including frames that were part of a fixation (i.e., which is traditionally defined as gaze being fixed to one region for at least 3 frames in a row). Eight regions were considered: the penalty taker's head, trunk and arms, kicking leg and foot, non-kicking leg and foot, the turf between the player and the ball, the ball, the turf directly in front of the ball, and remaining regions (see Dicks et al., 2010b; Savelsbergh et al., 2005; Savelsbergh et al., 2002). We planned to perform ANOVAs with repeated measures for the percentages of viewing times, but decided otherwise after processing of the gaze-tracker data (see *Gaze patterns* in the Results section below).

Results

Performance measures

Figures 1 and 2 illustrate the goalkeeping performances of the participants. As can be seen in Figure 1, the participants saved about one out of five penalty kicks. In addition, it appears that goalkeeping performance was enhanced in the high-probability conditions relative to the non- and equal-probability conditions. However, the ANOVA did not confirm this for the percentage of kicks saved, $F(3, 24) = 1.20$, $p = 0.33$, $\eta^2 = 0.13$. Also the ANOVA for the performance score failed to reach significance although the effect size was moderate, $F\ (3, 24) = 2.68$, $p = 0.07$, $\eta^2 = 0.25$ (Figure 2).

The participants clearly benefited from the situational information in anticipating the side to which the ball was kicked (Figure 3). Hence, the ANOVA for the percentage of dives toward the correct side was significant, $F\ (3, 24) = 3.90$, $p < 0.05$, $\eta^2 = 0.33$. Post hoc comparisons indicated that the participants more often anticipated the correct side in the two high-probability conditions than in the equal-probability condition. This was also found in comparison to the non-probability condition, but only for the 80r/20l high-probability condition.

The goalkeepers adapted the onset of their dive depending on the availability of situational information (Figure 4). That is, the ANOVA for movement onset was significant, $F(3, 24) = 5.22$, $p < 0.01$, $\eta^2 = 0.39$. Post-hoc comparisons indicated that in the non-probability condition participants dived significantly later (i.e., closer to foot-ball contact) as compared to both high-probability as well as the equal-probability conditions.

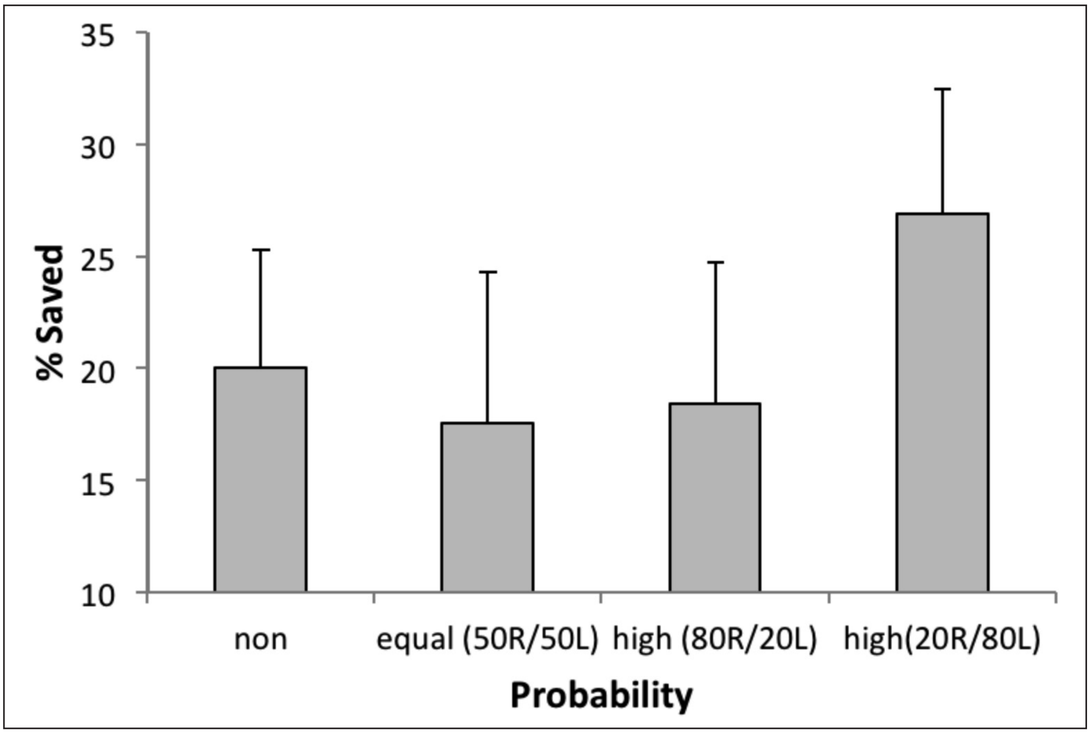

Figure 1. Percentage of saved kicks as a function of probability condition. Error bars represent standard error.

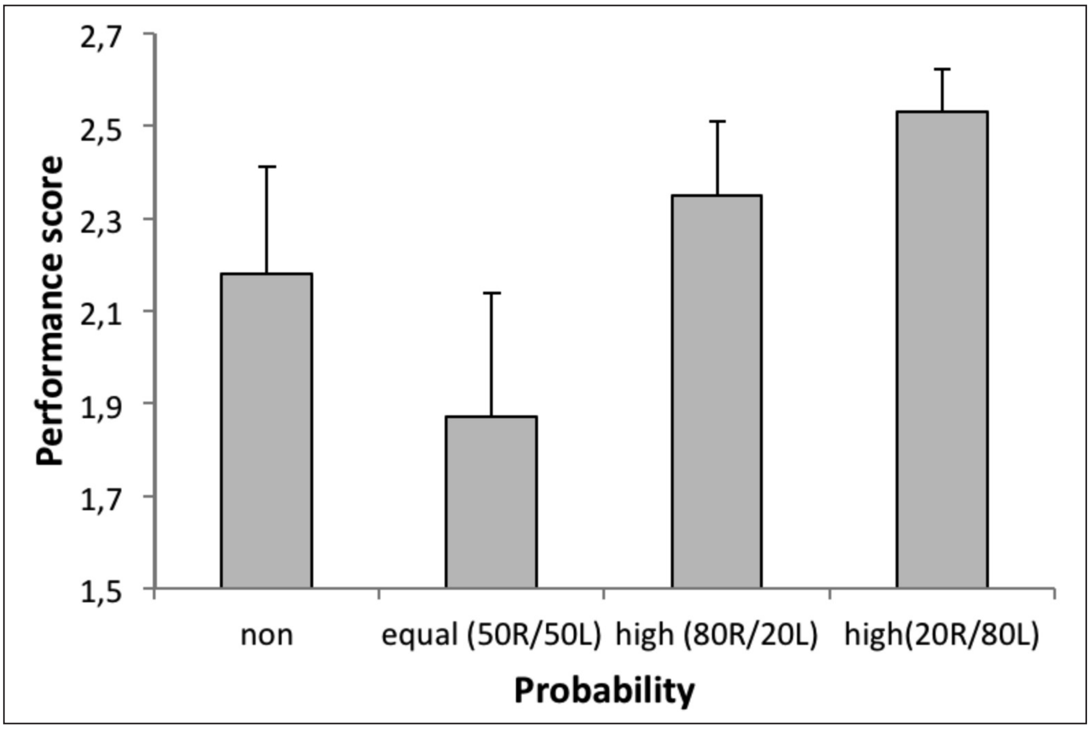

Figure 2. Performance score (out of 5) as a function of probability condition. Error bars represent standard error.

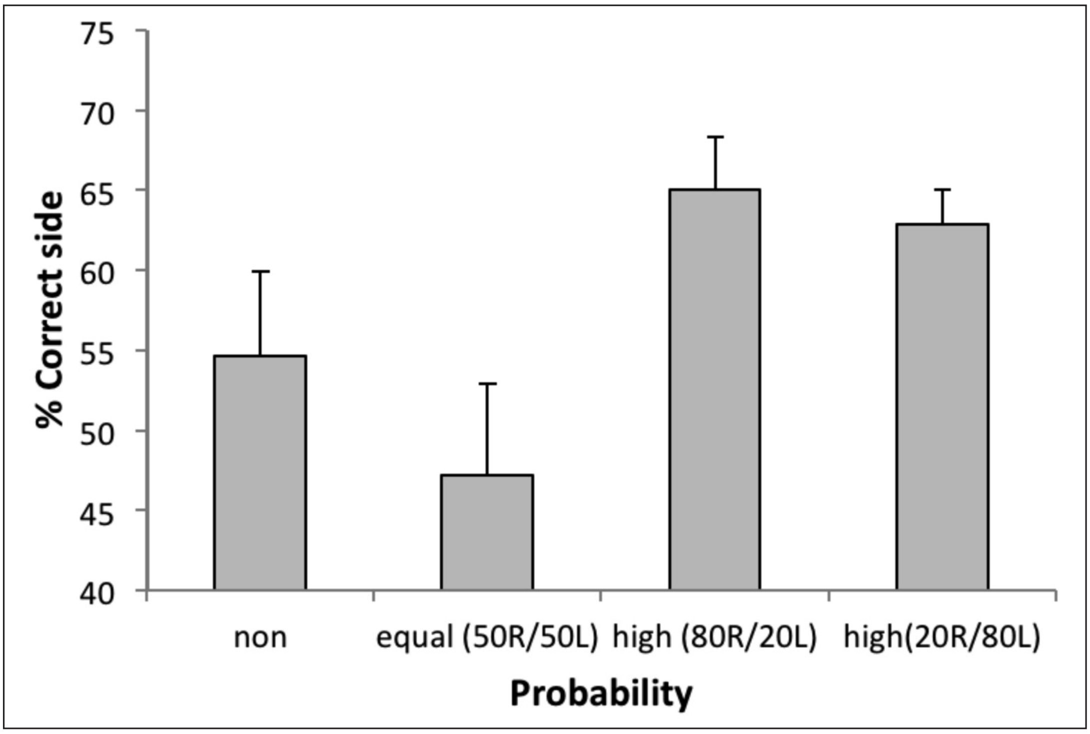

Figure 3. Percentage of anticipations to the correct side as a function of probability condition. Error bars represent standard error.

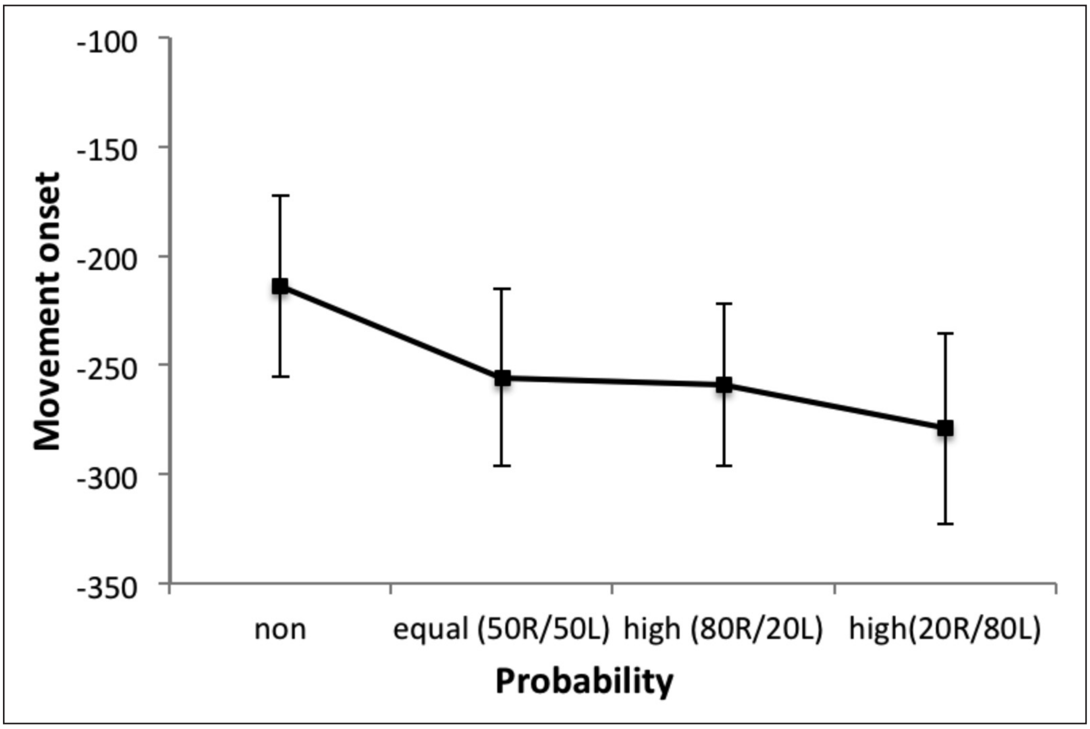

Figure 4. Movement onset as a function of probability condition. Error bars represent standard error.

Finally, we examined within the high-probability conditions whether saving performance differed for kicks that were directed to the high-probability side and kicks directed to the low-probability side. Two-tailed *t*-tests indicated significant higher performance scores, $t(8) = 4.04$, $p < 0.01$ and a higher percentage of dives to the correct side, $t(8) = 4.67$, $p < 0.001$, for kicks directed to the high-probability side than to the low-probability side (see Table 1). No signifcant differences were found for the percentage of balls saved, $t(8) = 1.40$, and movement onset, $t(8) = 0.33$.

Gaze patterns

Recording gaze using Mobile Eye in diving goalkeepers proved to be a technical challenge. As a consequence, and after careful perusal of the recordings, only the recordings from four participants were judged to be sufficiently complete and reliable. The gaze patterns for each of these individual participants are presented separately (see Figure 5a-d). It is important to caution for overgeneralisations; instead, the observations ought to be taken primarily as exploratory and as a guide for further research.

Like in previous work (e.g., Button, Dicks, Haines, Barker & Davids, 2011; Dicks et al., 2010b; Savelsbergh et al., 2002) patterns were highly variable both within and between participants. For example, the average time the participants spent looking at the head and upper body over the entire penalty kick ranged between 0% and 41%; between 0% and 27% for the kicking leg; between 0% and 15% for the non-kicking leg; between 15% and 83% for the ball (including the turf directly in front of the ball); and between 1% and 12% at the turf between the ball and the player.

Table I

Means (and Standard Error) of Performance for Kicks Directed to the Side with High and Low Probability in the High-Probability Conditions

	Side	
	High probability	**Low probability**
Saved balls (%)	24.4 (3.5)	15.7 (5.5)
Performance score	2.7 (0.1)	1.3 (0.3)
Dive to correct side (%)	71.6 (2.7)	31.0 (7.0)
Movement onset (ms)	-269 (27)	-274 (35)

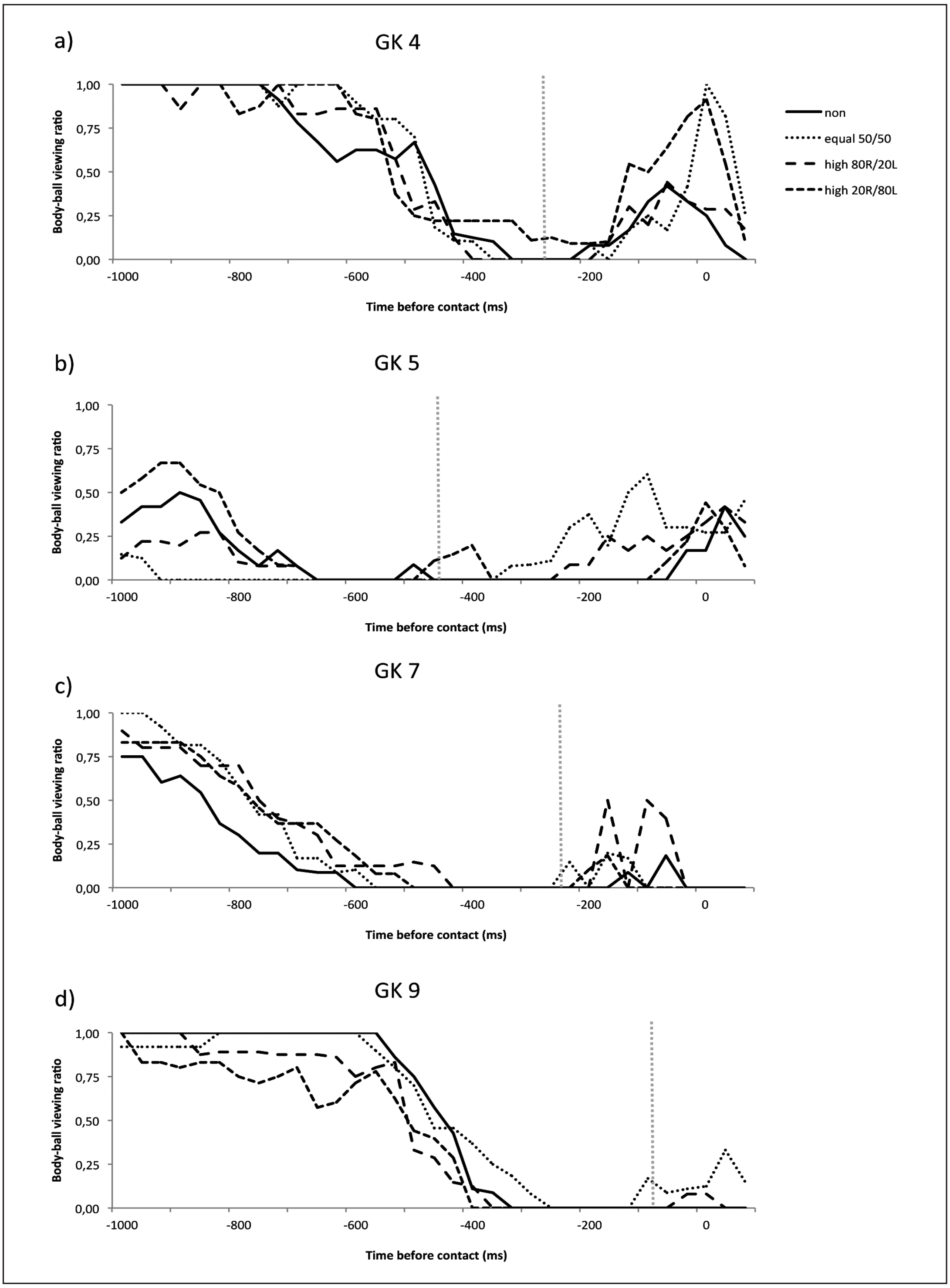

Figure 5. Ratio of viewing time between body areas and the ball unfolding during the kick for four individual participants as a function of probability condition. The dotted vertical line represents movement onset (average for all four conditions). See text for further explanation.

To reduce the dimensionality of these gaze patterns, we first constructed a measure that reflects how the participants divided gaze between the penalty taker's body and the ball, and then depicted how this evolved from the start of the run-up until the ball was contacted (for a similar method see Jovancevic-Misic & Hayhoe, 2009). To this end, for each frame a ratio of the mean percentage of time spent viewing at the opponent's body (sum of time spent viewing at the head, trunk, and legs) to the mean percentage of time spent viewing at the ball (including the turf directly in front of the ball) was calculated (i.e., by dividing the time spent viewing at the opponent's body by the summed times spent viewing at the opponent's body and the ball) for each of the four probability conditions separately. A high ratio close to 1 indicates that the participant primarily gazed at the body (see e.g., Figure 5a during the initial phase of the penalty), while a low ratio near to 0 points to gaze being directed to the ball (see e.g., Figure 5a around movement onset). In other words, a high ratio suggests that the goalkeeper participant' strongly relies on body information in order to try to intercept the ball.

Examination of the gaze pattern of the four participants reveals that early during the penalty taker's run-up to the ball gaze was predominantly directed to the body, possibly with the exception of GK5 (Figure 5b). Yet, with the unfolding of the run-up and kick, participants shifted their gaze away from the body toward the ball. Two-tailed *t*-tests confirmed the significant decrease in percentage of time spent viewing to the body from the first part (i.e., prior to 500 ms before ball-contact) to the second part (i.e., between 500 ms before ball contact and ball-contact) of the penalty kick, $t(3) = 7.65$, $p < 0.05$, while the increase for time spent looking at the ball failed to reach significance, $t(3) = -2.51$, $p = 0.08$. This pattern, which is reminiscent of the recent *in situ* observations by Dicks et al. (2010), seemed to have occurred irrespective of probability condition. Importantly, however, Figure 5 also indicates that considerable variability exists with respect to the *timing* of the gaze shift from a predominant body focus (i.e., for ratios exceeding 0.5) toward a predominant ball focus (i.e., for ratio smaller than 0.5). This variability, however, appears larger between participants than between probability conditions. That is, while GK4 and GK9 shifted gaze relatively late (i.e., between approximately 500 to 400 ms before ball-contact), GK5 and GK7 shifted gaze much earlier (i.e., before 700 ms). It is notable that the goalkeepers GK4 and GK9, who spent a relatively long time viewing at the body before they shifted gaze to the ball, performed better in the non-probability condition than in the high-probability conditions. By contrast, GK5 and GK7, who shifted gaze earlier and spent much longer time viewing at the ball, tended to perform better in the high-probability conditions than in the non-probability condition. This observation was confirmed by significant Pearson correlations between the moment of gaze shift (i.e., the time at which the ratio was 0.5) and the performance difference between the non- and high-probability conditions for the percentage of saves, $r(4) = 0.99$, $p< .01$, and the percentage of anticipations to the correct side, $r(4) = 0.91$, $p< .05$. The moment of gaze shift, however, was not related to movement onset of the goalkeeper.

Finally, goalkeepers who waited relatively long before shifting gaze from the body to the ball (i.e., GK4 and GK9) did so *later* in the non-probability condition compared to the high-probability conditions, whereas GK5 and GK7 who shifted their gaze to the ball early did so *earlier* in the non-probability condition compared to the high-probability conditions. This was confirmed by a significant Pearson correlation between the moment of gaze shift (i.e., time at which the ratio was 0.5) and the difference in the timing of gaze between the non- and high- probability conditions, $r(4) = 0.98$, $p<0.01$. This suggests that the variability in gaze patterns between the probability conditions is more strongly related to an individual goalkeeper's preference for using body relative to situational information, than to the accessibility of situational information per se.

Discussion

The general aim of the present experiment was to assess whether situational information about the penalty kicker's preference to shoot to one or the other side of the goal benefits penalty saving success, and more specifically whether it affects the goalkeeper's choice to dive to the correct side, the timing of dive onset, and gaze patterns directed to the kicker's body and the ball. Situational information improved the goalkeepers' success in diving to the same side as the ball, and the dive was initiated earlier with situational information available. Yet, it did not result in an increase in the percentage of saved kicks (albeit that the increment in the performance score just failed to reach significance). The exploratory analysis of the gaze patterns in four goalkeepers suggested systematic differences in time spent viewing to the body relative to the ball, but this variability might be more strongly related to goalkeepers' preference for body relative to ball flight information than to the availability of situational information *per se*.

Obviously, information about a kicker's side preference relates to where the ball will be placed. Therefore, the finding that with this information goalkeepers dived more often to the same side as the ball confirms that they were indeed able to exploit the situational information. At the same time, however, the lack of increase in the number of balls saved underlines that in this task success is not uniquely determined by spatial accuracy, but also entails temporal aspects (and/or diving skill). That is, saving a penalty kick involves a delicate trade-off between picking up spatial information about *where* to dive and deciding *when* to dive. On the one hand, the goalkeeper should not dive too early because the body information is insufficiently predictive with respect to the future ball trajectory. The side of the dive would then be a mere guess. On the other hand, the goalkeeper should not commit too late (i.e., after fully predictive information from ball flight is available) because it normally leaves insufficient time to reach the ball (Graham-Smith, Lees & Richardson, 1999). Accordingly, agile goalkeepers can wait longer before initiating the dive and therefore have more reliable information from the opponent's body movements (and early ball flight) available, resulting in better saving performance (Dicks et al., 2010c). The current study demonstrates that situational information can modify this delicate trade-off. With situational information about a kicker's side preference available goalkeepers commit themselves earlier, even though information from the kicker's body movements (and the ball) is less predictive. Possibly, the more enduring situational information makes the less predictive and more ephemeral body information more useful. Similarly, Alain and Proteau (1978) also reported earlier responses (i.e., shorter reaction times) in high-probability relative to low-probability conditions. In their study, participants had to hit one of two balls suspended from a ceiling as quickly as possible after a corresponding light was illuminated. Notice, however, that in this reaction time task there is no equivalent for body information that goalkeepers can typically exploit to anticipate the penalty kick. Hence, the present study is the first to demonstrate that situational information modulates the use of body information in an *in situ* time-constrained interception task (cf. Furley, Dicks, Stendtke & Memmert, 2012 for some suggestive evidence). Moreover, the observation that in the high-probability conditions, goalkeepers only dive in approximately 65% of the kicks to the same side as the ball (rather than the conveyed 80%[3]) indicates that situational information not simply replaces body (and ball) information. Instead, it points to the (not fully predictive) body information still being used, even when more reliable situational information is exploited.

[3] To make sure, the (average) actual distribution was 81%.

Although the current exploratory gaze analysis only involved four participants, the systematic shift from gazing the body in the early part of the run-up toward gazing the ball in the later part of the run-up (often before foot-ball contact) replicates previous observations of *in situ* penalty saving (Dicks et al., 2010b). Yet, the timing of this gaze shift did show clear inter-individual differences. It appeared that the performance of the two goalkeepers that shifted gaze relatively early, and hence could not exploit the more reliable body information, benefitted more from situational information than performance of the two goalkeepers that shifted gaze late and presumably relied more on body information. Hence, the relative amount of time spent looking at the body and ball across the run-up appears a function of the degree to which the individual goalkeepers use body information relative to situational information. By contrast, the availability of situational information per se did not seem to have a systematic effect on the spatio-temporal gaze characteristics. Obviously, however, the small number of participants considerably limits the power for detecting differences as function of situational information. Additional work is needed to substantiate these first exploratory observations.

In conclusion, the current study is the first to demonstrate that situational information potentially enhances the spatial and temporal aspects of interceptive actions *in situ*. It does not so by merely replacing other sources of anticipatory information, but by modulating the use of less predictive and more fleeting information from the opponent's body kinematics. The gaze analysis suggests that this modulation may involve a change in gaze patterns, most notably in the timing of the shift from looking to the opponent's body movement toward the ball. However, the limitations of the present research raise many issues for future work. First of all there is a need to substantiate and further delineate the effects of situational information on gaze. It is particularly relevant to further understand how situational information, which in fact is information that is stable over relatively larger time-scales, modulates the pickup of information that is more fleeting, and only available momentary, as is suggested by the present findings. It is for instance tempting to speculate that human perceptual systems are actually evolved to exploit information from different time-scales. For instance, recent findings in neuropsychology suggest that the dorsal and ventral visual systems should be distinguished primarily based on the type of information they pick up *and* the time-scale on which they operate rather than the functions they subserve (de Wit, Van der Kamp & Masters, 2011; Madary, 2011; but see Milner & Goodale, 2008). A second important issue is to consider the role of action capabilities. For example, Dicks et al. (2010c) have shown that the agility of the goalkeeper affects the timing of the dive. The current findings indicate that timing is also influenced by situational information, raising the issue of how the two interact. In this respect, it would be particularly relevant to examine more skilled goalkeepers than the intermediately skilled participants of the present study.

Finally, some potential applications are worthy of pointing out. The current results suggest that advising the goalkeeper about a penalty kicker's preference to shoot to one or the other side of the goal may be beneficial, at least for preferences that are sufficiently strong (i.e., ≥ 80%) to provide useful information. To this end, it is pertinent to keep systematic records of prospective opponents. Nonetheless, variability between goalkeepers in the use of body and situational information appears considerable (see also Button et al., 2011). Hence, to maximize its profits for penalty kicks in competition, it is recommended to consider each individual goalkeeper's information-using profile. In fact, it seems to us that current design can be easily adopted for training to better attune a goalkeeper to the situational information.

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