

# Gaze behaviour during the soccer penalty kick: An investigation of the effects of strategy and anxiety

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*Gaze behaviour of penalty takers who either adopted a goalkeeper independent or goalkeeper dependent strategy was compared for low and high anxiety conditions. Results showed clear performance advantages for the goalkeeper independent strategy as compared to the goalkeeper dependent strategy. Balls were shot further away from the goalkeeper and less saves were made. The superior performance of the goalkeeper independent strategy was associated with longer times spent viewing to the target area inside the goal and toward the ball, and shorter looking times at the goalkeeper. The moderate, but significant increase in anxiety, however, did not affect gaze behaviour and performance. The present experiment is the first to demonstrate that the benefits of the goalkeeper independent strategy, relative to the goalkeeper dependent strategy, result from more optimal gaze patterns.*

KEY WORDS: Attentional control theory, Far aiming, Movement control.

## Introduction

In soccer, a penalty kick is a free kick taken eleven meters out from the goal with only the goalkeeper of the defending team between the ball and the goal. The goalkeeper is not allowed to move forward until the ball is kicked, which provides the penalty kicker with an overwhelming advantage over the goalkeeper. Ball speeds of 80 to 100 km/hour allow the goalkeeper less than half a second to cover an area of almost 18m<sup>2</sup>. Astonishingly, however, in World Cup history only a mere 70% of penalty kicks is successfully scored

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(Jordet, Hartman, Visscher & Lemmink, 2007, see also Furley, Dicks, Stendtke, & Memmert, 2012, in an experimental setting). An analysis of more than 3000 penalty kicks over a period of 35 years in the German Bundesliga revealed only a slightly higher percentage of goals from penalty kicks (Kropp & Trapp, 1999). That is, despite the fact that the penalty situation profoundly favours (and purposely so!) the penalty taker, no more than 75% of the penalty kicks were successfully converted. The relatively low penalty success rate is largely attributed to the high anxiety level among penalty kickers, which is induced because penalty kicks often decide the winner of a match (Jordet *et al.*, 2007). Yet, some authors have argued that the success rate is also mediated by penalty kick strategy (Morya, Ranvaud, & Pinheiro, 2003, van der Kamp, 2006). Hence, the current study addressed the (interactive) influences of penalty kick strategy and anxiety on penalty kicking.

Penalty kickers use one of two different strategies to approach a penalty (van der Kamp, 2006; see also Kuhn, 1988; Morya *et al.*, 2003). In the *goalkeeper independent strategy*, penalty takers decide on a target area to kick the ball (e.g., in the top corners beyond the reach of the goalkeeper) prior to the run-up and uphold that decision irrespective of the goalkeepers' actions during the run-up. Alternatively, in the *goalkeeper dependent strategy* they make an initial choice for a target area, but continuously re-assess their choice relative to the goalkeeper's actions during the run-up. In the latter keeper-dependent strategy, the penalty kicker anticipates the side to which a goalkeeper will move so as to kick the ball to the opposite side.

Based on observations from an *in situ* simulated penalty kick task, which did not involve a goalkeeper, van der Kamp (2006) claimed that the keeper independent strategy is the more advantageous of the two strategies. Thus, the keeper independent strategy allows sufficient time to impeccably prepare and execute the kicking action, while in the keeper dependent strategy preparation and execution gets compromised when the actions of the goalkeeper necessitate an adjustment in kicking direction, especially when the goalkeeper commits him- or herself late during the run-up (see also Morya *et al.*, 2003; van der Kamp, 2011) or in stressful situations (Navarro, Miyamoto, van der Kamp, Morya, Ranvaud & Savelsbergh, 2012). This problem is further enhanced because more successful goalkeepers tend to wait relatively long before initiating the final dive towards the ball (Dicks, Button, & Davids, 2010; Savelsbergh, Williams, van der Kamp, & Ward, 2002; Savelsbergh, van der Kamp, Williams, & Ward, 2005).

Van der Kamp (2006) also put forward that the two strategies may invoke distinct patterns of gaze that directly influence the success of penalty kicks. As of today, this has not been examined yet. That is, research demonstrated that

both spatial (i.e., where a person fixates) and temporal gaze parameters (i.e., when and for how long a person fixates) are pertinent for the accuracy of aiming actions (for overviews, see Land, 2009; Mann, Williams, Ward, & Janelle, 2007; Vickers, 2007). With respect to penalty kicking, it has been shown that when gaze patterns are predominantly focused on the goalkeeper, this leads to the ball being placed nearer to the goalkeeper, providing the goalkeeper a better chance to block the ball. However, a prolonged focus on target areas of the goal was found to result in less centralised shots, offering the goalkeeper less opportunity to save the ball (Bakker, Oudejans, Binsch, & van der Kamp, 2006; Binsch, Oudejans, Bakker, Hoozemans, Savelsbergh, 2010a; Binsch, Oudejans, Bakker, & Savelsbergh, 2010b; see also van der Kamp, 2011; Wilson, Wood & Vine, 2009; Wood & Wilson, 2010, 2011). However, these studies did not compare the gaze patterns for the goalkeeper dependent and independent strategies. Van der Kamp (2006) hypothesised that penalty kickers who take on a keeper dependent strategy are likely to spend more time looking at the goalkeeper to anticipate or respond to his or her moves as compared to kickers who follow a keeper independent strategy and probably gaze longer toward the target area. Consequently, a penalty kicker is more liable to direct the ball within reach of the goalkeeper when employing a goalkeeper dependent strategy relative to a goalkeeper independent strategy. The current study is therefore the first study that directly assesses the untested conjecture that the goalkeeper independent strategy evokes different gaze patterns.

Gaze patterns may also mediate the negative effects of anxiety on penalty kick success rate. In this respect, an increasingly prominent framework for understanding the relationship between anxiety and performance is offered by attentional control theory (Eysenck, Derakshan, Santos, & Calvo, 2007; Oudejans & Nieuwenhuys, 2009). Eysenck *et al.* (2007; see also Corbetta & Shulman, 2002) distinguish two attentional systems. On the one hand, a goal-directed system is proposed that employs a top-down control of attention based on the performer's goals, expectations, and knowledge. A stimulus-driven system, on the other hand, controls attention in a bottom-up fashion predicated on salient sources of information. It is surmised that anxiety decreases the relative influence of the goal-directed system in favour of the stimulus-driven system in the control of attention. Consequently, rather than attending to goal-related sources of information, the performer's attention is pulled towards the more conspicuous information sources. The latter are often threat-related stimuli, which are not necessarily useful, or less so, for achieving the performer's goals. These changes in attention do not necessarily have to result in decrements in performance efficacy; through additional effort performance can be maintained even with suboptimal attention.

Wilson *et al.* (2009; see also Wood & Wilson, 2010, 2011) examined the anxiety-induced shift in reliance on the two attentional control systems for the penalty kick. They identified the goalkeeper as the threat-related stimulus (i.e., the source of anxiety). Hence, they argued that if high anxiety indeed leads to attention allocation becoming more stimulus-driven, then the penalty takers would spend more time looking at the goalkeeper in the high-anxiety compared to the low-anxiety situation. This hypothesis was roughly confirmed, but not unequivocally so. Thus, Wilson *et al.* (2009) observed that participants looked longer toward the goalkeeper in the high anxiety situation, a shift in attention that was associated with more centralised penalty kicks. In a second study, however, Wood and Wilson (2010) replicated this change in attention from a low-anxiety to a high-anxiety situation only when the goalkeeper was waving to attract the kicker's attention even though the goalkeeper stood still in the Wilson *et al.* (2009) study.

The work by Wilson and Wood leaves several issues that deserve further scrutiny. Most prominently, the potential interacting influence of penalty kick strategy was not taken into account. It is unknown from the studies of Wilson and Wood (Wilson *et al.*, 2009; Wood & Wilson, 2010) what strategy the kickers employed. By attracting attention, the active goalkeeper may have enticed the penalty kickers to more fully take up a keeper dependent strategy than the passive goalkeeper did (Wood & Wilson, 2010; cf. Wilson *et al.*, 2009). This raises the possibility that penalty kickers who are inclined to follow a keeper dependent strategy increase their focus of attention toward the threat-related goalkeeper, and more so than penalty kickers who use the goalkeeper independent strategy. By contrast, for penalty kickers who adopt a keeper independent strategy worrisome thoughts may be directed to missing the target. Instead of the goalkeeper, the threat-related or conspicuous stimuli would then include either goal post or the crossbar, or the wider space surrounding the goal. Significantly, when instructed to aim for the target area as accurately as possible and pressed not to *miss* the goal, penalty kickers were found to gaze more often to areas bordering the goal and produced more wide placements (Bakker *et al.*, 2006). In other words, it is plausible that the would-be sources of threat are not alike for the two penalty kick strategies. If this conjecture is correct, then alterations in attention and the accompanying changes in performance as a consequence of increased anxiety may differ depending on penalty kick strategy. Hence, a mixture of penalty kickers that prefer to use a goalkeeper dependent and goalkeeper independent strategy among the participants may have been responsible for the partly inconclusive results in previous work.

The aims of the present study were twofold. First, we examined whether the goalkeeper independent and dependent strategies indeed invoke different patterns of gaze. In addition, we asked whether, and if so how, an increase in anxiety affects these potentially different patterns of gaze. Clearly, to identify the most solid penalty kick strategy, we were also interested in the consequences of strategy and anxiety on penalty kick performance. To this end, two groups of participants made up of intermediate skilled soccer players who either preferred to use a goalkeeper independent or goalkeeper dependent strategy, took penalty kicks in a low and a high anxiety condition. Both gaze and kicking performance were measured. On the one hand, we hypothesised that participants who take up a goalkeeper independent strategy spend more time looking at the target area and possibly, during the run-up, at the ball (see Wood & Wilson, 2010). Participants who adopt a goalkeeper dependent strategy, on the other hand, were anticipated to spend more time gazing at the goalkeeper. This latter strategy was thought to lead to kicks entering the goalmouth in closer vicinity of the goalkeeper, whereas the goalkeeper independent strategy was predicted to lead to less centralised kicks. Following attentional control theory, we hypothesised that increases in anxiety would lead to attention being absorbed by the threat-related stimuli. In particular, participants employing a goalkeeper dependent strategy would show increased time looking at the goalkeeper. We reasoned that for penalty takers employing goalkeeper independent strategy who are expected to focus on target areas of the goal (e.g., the corner), the threat-related stimuli would most likely be the woodwork surrounding the target area (see e.g., Bakker *et al.*, 2006), such as the goalpost or crossbar. Accordingly, these players were predicted to pay more attention to these regions. Therefore, an increase in the amount of balls that either hit the woodwork or are being placed wide or over was expected for the goalkeeper independent strategy in the high anxiety condition. By contrast, for the goalkeeper dependent strategy, it was expected that balls would be placed closer to the goalkeeper.

## Methods

### PARTICIPANTS

Twenty volunteers (i.e., 8 defenders, 6 midfielders, 6 forwards) out of an initial group of 25 soccer players were assigned to either the goalkeeper independent group (mean age = 26.0 years, SD = 2.5; mean soccer experience = 16.0 years, SD = 4.3) or the goalkeeper dependent group (mean age = 26.2

years, SD = 2.4; mean soccer experience = 16.4 years, SD = 5.3) based on their self-reported preferred penalty kicking strategy (see *Procedure*). In addition, two goalkeepers (both 25 years of age, and with 17 and 18 years of experience) participated in the experiment. All participants were of intermediate skill level and played on a competitive level in the 9<sup>th</sup> tier of the regional soccer league in the Ruhr area, Germany. All players, who were right-footed except for one, regularly practiced penalty taking during training sessions, and seven had taken at least one penalty kick in matches during the current season. The participants provided written consent prior to the experiment, and were treated in accordance with the local institution's ethical guidelines.

## APPARATUS

The experiment took place at an indoor 5-a-side soccer facility. According to the rules of the German soccer association (DFB) for indoor soccer, the goal was 5.0 m in width and 2.0 m in height. The penalty mark was at 9 m from the goal line. A "FIFA approved" ball (size 5) was used.

To measure kicking performance, a PVC canvas was fixed to the net and covered the whole goalmouth. A CANON XHG1 digital camera (25 Hz) was positioned 1 m behind and 1 m to the side of the penalty mark to record where the ball entered the goalmouth (or the goalkeeper blocked the ball). A microphone, which was placed directly next to the ball on the penalty mark, was used to determine the moment of foot-ball contact.

ASL Mobile Eye (Bedford, MA) was used to measure the participants' patterns of gaze. 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 a 9-point grid projected onto the scene plane. 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  $\pm 1^\circ$  of visual angle and a precision of  $0.5^\circ$  recorded at 25Hz using a DV-recorder (DVCR; Sony GV-D1000E), which was attached to the participants' back in a tight-fitting backpack (i.e., during calibration the recorder was connected to the laptop). During testing, calibration checks were conducted after every 10<sup>th</sup> trial (or after participants reported a dislocation of the spectacles) by instructing the participants to look at specific locations on the goal. The measurement of Mobile Eye was synchronised with the micro-

phone by using a light emitting diode (LED) placed next to the penalty mark. The LED was switched on when the recording of the microphone was triggered, and also indicated the start of the trial to the participants.

The Wettkampf-Angst-Inventar State (WAI-S, see Ehrlenspiel, Brand & Graf, 2009) and the anxiety “thermometer” (Houtman & Bakker, 1989) were used to determine the participants’ anxiety levels. The WAI-S is the German version of the Competitive State Anxiety Inventory-2 (CSAI-2; Martens, Burton, Vealey, Bump, & Smith, 1990).

## PROCEDURE AND DESIGN

After providing informed consent, the participants were interviewed about their preferred penalty kick strategy. They were first asked to portray as completely as possible their normal penalty kicking strategy. Subsequently, the differences between goalkeeper dependent and independent strategies were explained, and they were asked which of these strategies best described their preferred penalty kicking strategy. Participants were then assigned to either the goalkeeper dependent or goalkeeper independent group based on their preferred strategy. A participant was excluded from participation in the case there was ambiguity or doubt with respect to the nature of the preferred penalty kicking strategy. Additionally, participants rated their penalty kicking skills on a 10-point scale (i.e., 0- very poor, 10- very strong).

After a 5-minute warm up, participants were instructed to take the penalty kicks as they would normally do by using their preferred strategy. They were then fitted with the Mobile Eye and followed the calibration procedure. After calibration, they took 5 shots on goal without the goalkeeper to familiarise themselves with the equipment. The goalkeepers were instructed to try to anticipate and save the penalty kicks as they would normally do; yet they were instructed not to start diving during the early portion of the run-up. In addition, the goalkeepers were required to standardise their posture at the beginning of each trial by stretching the arms to the side at shoulder height (van der Kamp & Masters, 2008).

The participants took two blocks of 10 penalty kicks. Before the start of each block, they completed the WAI-S and the anxiety thermometer. One block was performed under low anxiety conditions, whereas the other took place under high anxiety conditions; the order of these was counterbalanced within groups. Before the start of each block, the participants were briefly reminded of the general instructions. For the high anxiety condition, they were told that their performance score would serve as input for an algorithm

that computes penalty taking skill, the outcome of which would be used for comparison with other players, and posted on a public leader board (i.e., most of the participants knew each other). Finally, a prize of 50€ for the player with the highest penalty kicking skill was offered. For the low anxiety condition, participants were told that these kicks served to establish a baseline measure of their performance and to check the accuracy of the recording system. In both conditions, the instructions were repeated after the 5<sup>th</sup> trial.

## DATA ANALYSIS

Video recordings were used to categorise each penalty kick as a score, a save or a miss, and as being directed to the same or opposite side of the goalkeeper dive. Subsequently, screenshots were made for the moment the ball passed the goal line or was blocked by the goalkeeper, and WINalyze Automatic Motion Analysis software was used to determine the distance the ball landed from nearest body part of the goalkeeper (in cm). In the case the ball was blocked, the distance to the goalkeeper was set to 0. Finally, kicks that completely missed the goal were not included in these analyses<sup>1</sup>

WINalyze software was used for a frame-by-frame analysis of the POG recordings. A gaze fixation was defined as three or more consecutive frames in which POG remained directed toward one of the following regions (see Vickers, 1996): goalkeeper, area inside the goal, area outside the goal, the ball and the ground floor between the penalty mark and the goal line. Gaze fixations on the woodwork of the goal were not defined as a separate category, but included in the third category (i.e., area outside the goal), because the time participants focused on the goalposts or the crossbar was negligible (i.e., < 1%). The remaining frames (i.e. 7.6%) were unidentified. Additionally, in order to establish the spatio-temporal properties of the participants' gaze during the penalty kick, each trial was divided into three phases (see Savelsbergh *et al.*, 2002; Wilson & Wood, 2010). The preparatory phase started at the moment at which the participants first looked at the illuminated LED next to the ball and ended when they started the run-up to the ball. The middle or approach phase started with the run-up and ended at 600 ms before foot-ball contact, because it is from approximately this moment that goalkeeper-induced alternations in initial kick direction may compromise kick accuracy (van der Kamp, 2006). The late or execution phase lasted

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<sup>1</sup> The use of default values for these misses did not result in (statistically) different patterns of results.



between 600ms before foot-ball contact until foot-ball contact (as indicated by a peak in the auditory signal). For each phase separately, the percentage of time of gazing at each of five regions was calculated.

Intra-individual means of the dependent measures were submitted to repeated measure ANCOVAs with strategy as a between-subject factor, and anxiety, phase and/or region as within-subject factors. The self-rating of penalty kicking skill was used as covariate, since preliminary analysis had shown that the participants of the goalkeeper independent group tended to rate their skill higher than participants of the goalkeeper dependent group,  $t(16) = 1.69$ ,  $p = .055$ . The significant positive correlation between the self-rating of penalty skill and the total of number of penalty kicks scored in the experiment,  $r(18) = .52$ ,  $p < .03$ , lends further credence to the validity of the self-rating measure. A Huyn-Feldt correction to the degrees of freedom was applied in the case of any violations of sphericity and partial eta-squared ( $\eta_p^2$ ) values were computed to determine the proportion of total variability attributable to each factor or combination of factors. Post-hoc comparisons were made using the Tukey's HSD test ( $p < .05$ ).

## Results

Out of the 400 shots, 247 were scored, 91 were blocked, and 62 completely missed the goal. The latter were excluded from the analysis of shot accuracy (in cm distance from the goalkeeper). Additionally, one participant from the goalkeeper dependent group was excluded from analysis, because he did not comply with the instructions (i.e., the participant never looked at the goalkeeper, which is logically impossible for a goalkeeper dependent strategy). Finally, due to technical problems with the Mobile-eye, POG data for a second participant of the goalkeeper dependent group was lost.

### ANXIETY

To verify that the anxiety manipulation indeed resulted in higher levels of perceived anxiety, the scores for the anxiety thermometer and the WAI-S (i.e., cognitive anxiety, confidence, and somatic anxiety) were submitted to separate 2(strategy: goalkeeper dependent, goalkeeper independent) x 2(anxiety: low, high) ANCOVAs with repeated measures on the last factor and the rating of penalty kicking skill as covariate. This revealed a significant effect for anxiety on the score of the anxiety thermometer,  $F(1, 15) = 4.91$ ,  $p <$

.05;  $\eta_p^2 = .25$ ), which confirmed increased levels of anxiety in the high anxiety condition. The WAI-S cognitive anxiety score,  $F(1, 15) = 4.70$ ,  $p < .05$ ,  $\eta_p^2 = .24$ , and the WAI-S confidence score,  $F(1, 15) = 9.21$ ,  $p < .01$ ,  $\eta_p^2 = 0.38$ , were also found significantly higher in the high anxiety condition, whereas the WAI-S somatic score was not (see Table I). The increases in anxiety were comparable, but perhaps at the lower end of those reported in previous work using these measures (e.g., Koedijker, Oudejans, & Beek, 2007; Pijpers, Oudejans, Holsheimer & Bakker, 2003; Wilson *et al.*, 2009; Wood & Wilson, 2010). No effects of strategy and self-evaluation were found.

TABLE I  
Mean Scores (and SE) on the Anxiety Thermometer and WAI-S Items  
for the Low and High Anxiety Conditions.

	Thermometer (mm)	WAI-S: Cognitive	Confidence	Somatic
Low Anxiety	21 (3.4)	5.0(0.5)	11.4 (0.4)	5.7 (0.5)
High Anxiety	33 (5.0)	6.8 (0.6)	9.6 (0.5)	5.9 (0.6)

## PERFORMANCE

Separate 2 (strategy: goalkeeper dependent, goalkeeper independent) x 2 (anxiety: low, high) ANCOVAs with repeated measures on the last factor, and the self-rating of penalty taking skill as a covariate for the number of scores, saves and misses revealed that significant more balls were saved for the goalkeeper dependent strategy compared to the goalkeeper independent strategy,  $F(1, 15) = 5.4$ ,  $p < .05$ ,  $\eta_p^2 = .27$ . The number of saves was also affected by the self-rating,  $F(1, 15) = 10.3$ ,  $p < .01$ ,  $\eta_p^2 = .41$ , as was the number of scores,  $F(1, 15) = 8.97$ ,  $p < .01$ ,  $\eta_p^2 = .37$ . Numerically, minor performance decrements might have become apparent (Fig. 1), but no reliable effects related to anxiety were found.

A similar ANCOVA for the number of kicks directed to the same side as the goalkeeper moved only revealed a significant effect of strategy,  $F(1, 15) = 4.67$ ,  $p < .05$ ,  $\eta_p^2 = .24$ , indicating that participants of the goalkeeper independent group directed the ball more often to side the goalkeeper moved than the participants of the goalkeeper dependent group (i.e., 74% and 66%, respectively). A second ANCOVA revealed a significant effect of strategy for the distance the ball landed away from the goalkeeper,  $F(1, 15) = 6.34$ ,  $p < .05$ ,  $\eta_p^2 = .30$ , with also the self-rating of penalty taking skill being significant,  $F(1, 15) = 10.2$ ,  $p < .01$ ,  $\eta_p^2 = .41$ . Participants who employed a

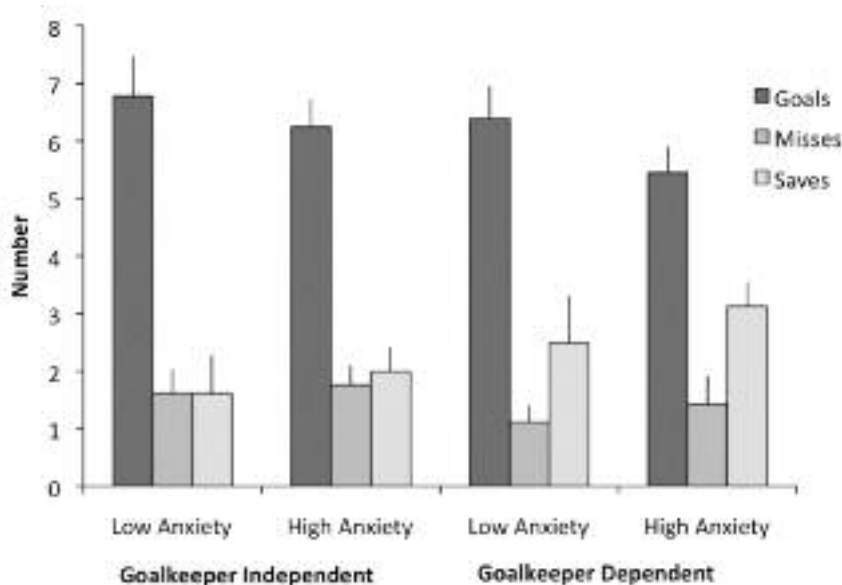


Fig. 1. The number of penalty kicks scored, saved and missed as a function of strategy and anxiety. Error bars indicate standard errors.

goalkeeper independent strategy tended to direct the ball further from the goalkeeper (Fig. 2). Again, no effects of anxiety were found.

#### GAZE BEHAVIOUR

The percentage of time spent viewing at the goalkeeper, area inside the goal, area outside the goal, the ball and the ground floor between the ball and goal were submitted to separate 2 (strategy: goalkeeper dependent, goalkeeper independent) x 2 (anxiety: low, high) x 3 (phase: preparatory, approach, execution) ANCOVAs with repeated measures on the last two factors and the self-rating of penalty skill as covariate. This showed clear differences in gaze behaviour as function of strategy (Fig. 3). Accordingly, for the percentage of time spent viewing at the goalkeeper, significant effects of strategy,  $F(1, 15) = 21.1, p < .0001, \eta_p^2 = .59$ , and phase,  $F(2, 14) = 27.7, p < .0001, \eta_p^2 = .65$ , were found. Post hoc indicated that the penalty kickers who used the goalkeeper independent strategy looked less at the goalkeeper than those employing the goalkeeper dependent strategy (i.e., 15.2% and 41.0%,

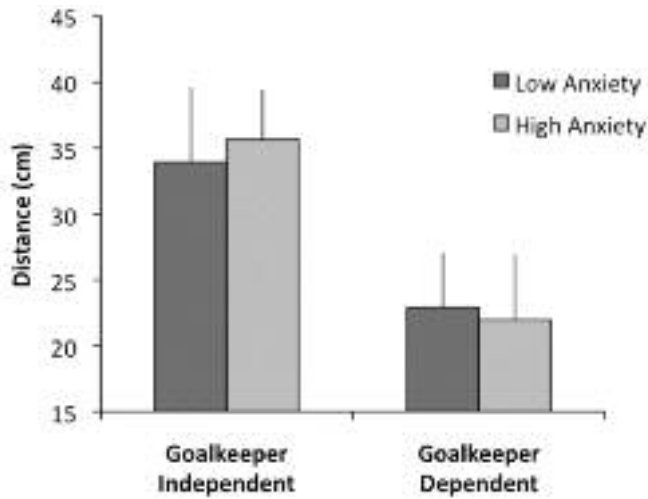


Fig. 2. The distances (in cm) the ball landed from the goalkeeper as function of strategy and anxiety. Error bars indicate standard errors.

respectively). In addition viewing times to the goalkeeper decreased for each phase closer to foot-ball contact irrespective of strategy (i.e., 48,6%, 32,7% and 11,8% for the preparatory, approach and execution phase, respectively). A significant effect of self-rating,  $F(1, 15) = 5.58, p < .05, \eta_p^2 = .27$ , indicated that participants who rate themselves as skilled, spent less time viewing at the goalkeeper. Anxiety did not affect the time spent viewing at the goalkeeper (Fig. 3).

For the percentage of time spent viewing at the area inside the goal a significant interaction of strategy and phase was revealed,  $F(2, 14) = 8.1, p < .05, \eta_p^2 = .35$ . Post hoc indicated that the goalkeeper dependent strategy in comparison to the goalkeeper independent strategy was associated with shorter viewing times at the target areas inside the goal, but only during the preparatory phase (i.e., 25,0% and 36,3%, respectively). In addition, the viewing times toward these areas significantly decreased between the subsequent phases. Self-rating significantly affected viewing times to the area inside the goal,  $F(1, 15) = 11.7, p < .01, \eta_p^2 = .44$ , also in interaction with phase,  $F(2, 14) = 4.65, p < .05, \eta_p^2 = .24$ . This indicated that participants who rated themselves as skilled, spent more time viewing at the area inside the goal, particularly in the preparatory phase. No effects of anxiety were discerned. Unlike the area inside the goal, for the percentage of time spent viewing at areas outside the goal no significant effects were found.

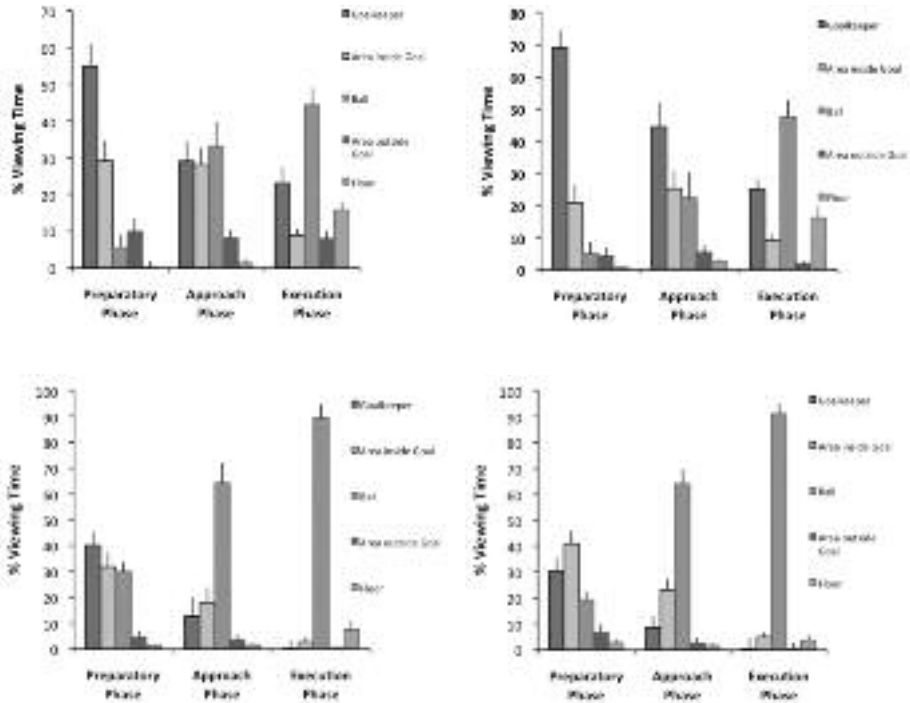


Fig. 3. The percentages of time spent viewing at the different regions of interest as function of phase for the goalkeeper dependent strategy in the low (top, left panel) and high anxiety condition (top, right panel) and the goalkeeper independent strategy in the low (bottom, left panel) and high anxiety condition (bottom, right panel). Error bars indicate standard errors.

Strategy also significantly affected the time spent viewing at the ball,  $F(1, 15) = 44.2$ ,  $p < .0001$ ,  $\eta_p^2 = .75$ , with participants looking twice as long at the ball when they acted according to a goalkeeper independent strategy than according to a goalkeeper dependent strategy (i.e., 58.3% and 26.4%, respectively). Significant effects were also found for phase,  $F(2, 14) = 6.21$ ,  $p < .05$ ,  $\eta_p^2 = .29$ , and the interaction between strategy and phase,  $F(2, 14) = 6.91$ ,  $p < .05$ ;  $\eta_p^2 = .32$ ). Post hoc indicated that gaze duration to the ball increased for each subsequent phase contact, with the increase being much steeper for the goalkeeper independent strategy (i.e., from 20.6% to 90.3%) than for the goalkeeper dependent strategy (i.e., from 5.3% to 46.0%). No further effects were found.

Finally, the analysis for the time spent viewing at the floor only revealed a significant interaction effect of phase and strategy,  $F(2, 14) = 4.6$ ,  $p < .03$ ,

$\eta_p^2 = .28$ . Post hoc indicated that the participants who used the goalkeeper independent strategy spent less time viewing at the floor between ball and goal line than participants who used the goalkeeper dependent strategy, but only in the execution phase (i.e., 5.6% and 16.0%, respectively).

#### ASSOCIATION BETWEEN PERFORMANCE AND GAZE BEHAVIOUR

Pearson product correlations were calculated between the kicking accuracy measure (i.e., distances to the goalkeeper) and the total viewing durations (in ms) to each of the five regions. These calculations were conducted irrespective of strategy, phase and anxiety. This revealed significant relationships between the distance the ball landed from the goalkeeper and the total viewing durations for the goalkeeper,  $r(18) = -.13$ ,  $p < .05$ , the ball,  $r(18) = .12$ ,  $p < .05$ , and the area inside the goal,  $r(18) = .65$ ,  $p < .01$ . Accordingly, the less time a participant spent viewing at the goalkeeper, and the more time to the ball, and in particular to the inside area of the goal (note the high proportion of explained variance), the farther away the ball was directed from the goalkeeper.

#### Discussion

The current study provides further evidence for the superiority of a goalkeeper independent strategy, in which penalty kickers choose and maintain a target area irrespective of the actions of the goalkeeper during the run-up, over and above a keeper dependent strategy, during which the penalty kicker tries to place the ball to the opposite side of the goal that the goalkeeper dives (Morya *et al.*, 2003; van der Kamp, 2006, 2011). In particular, in the goalkeeper independent strategy the ball was placed further away from the goalkeeper and less saves were made. In fact, this performance advantage for the goalkeeper independent strategy transpired despite that the goalkeeper more often defended the correct side of the goal. Put differently, the goalkeeper independent strategy is superior to the goalkeeper dependent strategy, even though the direction of the kick is easier to anticipate for the goalkeeper. It seems that the ball is more accurately directed to areas beyond the goalkeeper's reach, even if it tends to be placed to the same side the goalkeeper dives. Van der Kamp (2006, 2011) showed that an important reason for this superiority is that anticipating the action of the goalkeeper decreases penalty kick performance, because there is insufficient time left to modify the initially decided kick direction late in

the run-up to the ball (when the information specifying the direction of the goalkeeper's dive becomes available).

In the current study, we directly examined whether gaze behaviour is an additional factor that underlies the relative benefits of the goalkeeper independent over the goalkeeper dependent strategy. Visual attention is usually highly correlated to direction of gaze (Henderson & Hollingworth, 1999). The pertinent source of information to attend to obviously differs between the two strategies, the target area and goalkeeper being indicated for the goalkeeper independent and dependent strategy, respectively. Accordingly, the amount of gaze directed toward the goalkeeper and target areas are likely to differ significantly between the two strategies. The present study indeed substantiates these contentions. Thus, the penalty kickers who used a goalkeeper independent strategy spent more time looking at the target areas inside the goal, while the kickers of the goalkeeper dependent group looked longer to the goalkeeper. Importantly though, these gaze preferences were most pronounced during the preparatory phase, that is, before the actual run-up to the ball. During the approach phase and especially in the execution phase, gaze shifted towards the ball such that by the end of the run-up, the kickers in the goalkeeper independent group focused almost exclusively on the ball. By contrast, kickers who employed a goalkeeper dependent strategy kept looking at the goalkeeper for a significant proportion of time. Hence, the anticipated longer looking times at the target areas late in the run-up of the approach and execution phase did not show up (cf. Bakker *et al.*, 2006; Wilson *et al.*, 2009). In all likelihood, this is due to presence of an actual run-up or approach to the ball, whereas in most previous studies penalty kickers took only one step (for a similar reasoning, see Wood & Wilson, 2010).

The observed gaze patterns are roughly consistent with arguments by Wood and Wilson (2010, see also 2011) that the preparatory phase is the critical period for forming an aiming intention, that is, for 'looking ahead' to choose the direction of the kick. During the subsequent approach and execution phase, however, information is needed to allow the ball to be struck in such a manner that the (stored) aiming intention is achieved. The present study delineates this general format for the two penalty kick strategies. On the one hand, kickers that act according to the keeper independent strategy primarily, but not exclusively, look at the intended target areas in the preparatory phase. Possibly, this sets up the aiming-shooting accuracy relationship, as Wood and Wilson (2010) have argued. Nonetheless, they do still attend to the goalkeeper, suggesting that in constructing their aiming attention, they do not entirely ignore the goalkeeper. For example, it has been shown that a goal-

keeper's position relative to the goal's centre or their posture may (perhaps without the kicker being aware) affect the direction of the kick (Masters, van der Kamp, & Jackson, 2007; van der Kamp & Masters, 2008). The goalkeeper, however, is mostly ignored in the subsequent phases, where gaze is almost exclusively directed to the ball in order to optimise the control of the accuracy and pace of the kicking movement. This interpretation is supported by evidence from other interceptive aiming tasks, such as golf putting and cricket batting, that emphasises the importance of gazing at the ball for accurate aiming (e.g., Vickers, 1996; Croft, Button & Dicks, 2010). Because there is no need to interrupt gaze at the ball in order to confirm or amend the aiming intention, accuracy of the kick is better preserved for the keeper independent strategy. Kickers who follow a keeper dependent strategy, on the other hand, spent more time looking at the goalkeeper than at the target areas in the preparatory phase, which might negatively affect the aiming-shooting accuracy relationship. Yet, more unfavourable for the control of kicking accuracy is the need to continuously adjust the aiming intention to the goalkeeper's actions in the approach and execution phases. As a consequence, kickers using a keeper dependent strategy spent significantly less time viewing at the ball than those who use a keeper independent strategy; they gaze at the goalkeeper and the turf between the ball and goal instead (possibly the later region provides the opportunity to glance at both the goalkeeper and the ball using peripheral information). In all likelihood, this type gaze behaviour is less than optimal or disruptive with respect to the control and accuracy of the kicking movements. This is supported by significant positive and negative relationships between kicking accuracy and the amount of time spent looking at the ball and target areas, and the goalkeeper, respectively. In sum, the present study is the first to demonstrate that the two penalty kick strategies evoke distinct patterns of gaze, the particulars of which allow for more optimal control of the kicking movements in the case of the keeper independent strategy as compared to the keeper dependent strategy.

The present study also aimed to assess potential differential effects of increased levels of anxiety on the two penalty kick strategies. In this regard, attentional control theory holds that enhanced anxiety decreases the influence of the goal-directed attention in favour of a greater attention for conspicuous, threatening stimuli. Suboptimal attention, however, does not necessarily lead to decrements in performance because with additional effort performance may be maintained (Eysenck *et al.*, 2007). In view of that, Wilson and co-workers (Wilson *et al.*, 2009; Wood & Wilson, 2010) demonstrated for the penalty kick that an increase in looking times toward the goalkeeper is accompanied by significant decrements in kicking accuracy.



However, because the goalkeeper independent and dependent strategy present distinct sources of threat, we reasoned that increased anxiety would differently affect attentional control viz. gaze behaviour and consequently kicking performance for the two strategies. However, the current study did not reveal any change in gaze behaviour, nor a decline in penalty kick performance for increased levels of anxiety. Unfortunately, the most likely cause for the lack of result is that, albeit significant, the increase in anxiety was only moderate, and perhaps insufficient to alter attentional control and consequently performance. This is likely to be considered a methodological shortcoming, but not uniquely so. Although commonly used in this type of research (e.g. Wilson et al., 2009), the current procedure of using a public leader board in combination with a monetary award by no means is representative for the experienced levels of anxiety in a competitive penalty shoot out. Accordingly, also prior work using this method must be interpreted with caution; the adopted procedures may in fact lead to underestimations of the debilitating effects of performing under high-pressure. Having the participants perform in front of a loud participative audience that openly supports or boos the participants may be more effective in approaching the desired anxiety levels (Baumeister & Steinhilber, 1984; Navarro et al., 2012). Nevertheless, previous studies with similar levels of moderate anxiety have reported adverse effects in performance. This suggests that inter-individual variability exists in how participants cope with enhanced anxiety (see also Navarro et al., 2012). Often this variability is attributed to differences in state anxiety. Nonetheless, from the perspective of social identification theory (Steele, 1997), it is tempting to speculate that another source of variability is stereotype threat. Basically, social identification theory holds that an individual, who is confronted with a negative stereotype about the group he or she identifies with, is likely to suffer performance decrements (e.g., Beilock & McConnell, 2004; Steele & Aronson, 1995). The current participants were of German nationality, whereas previous work mostly involved English or Dutch soccer players. In international competitions, German soccer players have nearly always been successful in penalty kicking, whereas English and Dutch players are notorious for missing penalty kicks (Jordet, 2009). These positive and negative national stereotypes may affect an individual participant's penalty kicking performance, making English and Dutch more liable to choking under pressure than Germans. In terms of attentional control theory this would be due to German penalty kickers having more attentional resources available for increasing effort to avoid deterioration of performance (cf. Eysenck, 1996). Alternatively, but less likely, anxiety may increase the probability that a penalty kicker spontaneously shifts toward using a

keeper dependent strategy rather than a keeper independent strategy. This might have occurred in the study by Wilson *et al.* (2009; see also Wood & Wilson, 2010), in which no restrictions were imposed on penalty kick strategy. In the present study, however, the participants were pressed to act according to their preferred strategy, and hence, no shift to using the less optimal goalkeeper dependent strategy could occur.

To conclude, the present study re-affirms the superiority of the goalkeeper independent strategy over the goalkeeper dependent strategy for penalty kicking. Clearly, this advantage is associated with patterns of gaze behaviour in the goalkeeper independent strategy being more optimal for controlling the accuracy with which the ball is kicked. Whether this advantage really upholds under increased anxiety awaits further testing in more taxing anxiety situations.

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