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The development of a method for identifying penalty kick strategies in association football

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Abstract
Penalty takers in association football adopt either a keeper-independent or a keeper-dependent strategy, with the benefits of the keeper-independent strategy presumed to be greater. Yet, despite its relevance for research and practitioners, thus far no method for identifying penalty kick strategies has been available. To develop a validated and reliable method, Experiment 1 assessed characteristics that observers should use to distinguish the two strategies. We asked participants to rate 12 characteristics of pre-recorded clips of kicks of penalty takers that used either a keeper-independent or keeper-dependent strategy. A logistic regression model identified three variables (attention to the goalkeeper, run-up fluency and kicking technique) that in combination predicted kick strategy in 92% of the penalties. We used the model in Experiment 2 to analyse prevalence and efficacy of both the strategies for penalty kicks in penalty shoot-outs during FIFA World Cups (1986–2010) and UEFA Football Championships (1984–2012). The keeper-independent strategy was used much more frequently (i.e., 78–86%) than the keeper-dependent strategy, but successes did not differ. Penalty takers should use both the strategies to be less predictable. Goalkeepers can use the developed model to improve their chances to succeed by adjusting their behaviour to penalty takers' preferred penalty kick strategy.

Keywords: *penalty kicks, performance analysis, visual anticipation, penalty kick strategy*

Penalty kicks in association football are of interest in biomechanics, sport science and applied experimental psychology (Lees, Asai, Andersen, Nunome, & Sterzing, 2010; Memmert, Hüttermann, Hagemann, Loffing, & Strauss, 2013). The kick strategy of the penalty taker is commonly distinguished as being either keeper-dependent or keeper-independent (Kuhn, 1988; van der Kamp, 2006). In the keeper-dependent strategy, a penalty taker chooses a target area (e.g., the bottom right corner) before or during the run-up and continuously (re-)assesses the target area relative to the goalkeeper's actions. That is, the penalty taker anticipates the movement direction of the goalkeeper and intends to kick the ball to the opposite side. In the keeper-independent strategy, a penalty taker decides on a target area to kick the ball before the run-up (or even before the match) and maintains that decision irrespective of the goalkeepers' actions during the run-up.

Although this distinction is common in the scientific literature and football, the prevalence and success of the two penalty kick strategies are unclear. This is because of a lack of a valid and reliable method for distinguishing the two strategies. Differentiating between the kick strategies would be of both scientific and applied interest. This would allow researchers to identify determinants of successful kicks (e.g., kick coordination, patterns of gaze, anticipation, decision making) especially under high pressure. In addition, practitioners in professional football could distinguish penalty kick strategies and so inform coaching, training and scouting. Many goalkeepers in national and international competition keep records about opponents' kicking preferences, such as direction and speed of the kick (Kuper & Szymanski, 2009). These records tend not to include penalty takers' strategic approaches. Knowledge of such approaches (e.g., opponent A tends to kick to the right irrespective of the

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goalkeeper's actions, or opponent B prefers to wait for the goalkeeper to move) could increase a goalkeeper's chances of saving kicks.

Kuhn (1988) used ball speed (Castillo, Oña, Raya, Bilbao, & Serra, 2010) to demarcate the two strategies. After analysing 66 penalty kicks from European league club matches, he concluded that the keeper-dependent strategy constitutes about three-quarters of penalty kicks. While ball speed could distinguish strategies (even though a keeper-dependent strategy does not necessarily preclude a forceful kick), it is not the only distinctive feature. Consequently, Kuhn's (1988) estimate of the prevalence of keeper-dependent and keeper-independent strategies needs corroboration. The present research aimed to address this deficit. We did this in two steps. First, we identified the key characteristics that combine to demarcate penalty kick from a controlled experimental set-up during which penalty takers were instructed which strategy to use. Second, we then used these key characteristics to assess the prevalence of the two penalty kick strategies in all penalty shoot-outs of the UEFA Championship and the FIFA World Cup from 1982 to 2012.

In addition, this research compared outcomes of each strategy. Given the absence of a valid and reliable method for identifying kick strategies, it is not known which of the two strategies is more effective. Strong claims have been made about the purported risk and/or efficacy of the keeper-independent strategy compared with the keeper-dependent strategy. Van der Kamp (2006) reasoned that a keeper-dependent strategy demands a late modification of the kicking action during the run-up if the goalkeeper moves late. Accordingly, an investigation of a simulated penalty kick task showed superior kick accuracy for the keeper-independent strategy. The keeper-dependent strategy gives penalty takers not enough time to modify the intended kicking action (see also van der Kamp, 2011). Semi-professional players require at least 400–600 ms to modify the kicking action, a time interval that is prolonged under high pressure (Navarro et al., 2012). Consequently, if a goalkeeper starts movement within half a second of foot–ball contact, the use of a keeper-dependent strategy will result in a suboptimal kick. Note that goalkeepers who are more successful in saving penalty kicks tend to move late, i.e., within 250 ms before foot–ball contact (Dicks, Button, & Davids, 2010; Morya, Bigatão, Lees, & Ranvaud, 2005; Savelsbergh, van der Kamp, Williams, & Ward, 2005).

A further characteristic that differentiates the efficacy of the two strategies is the spatio-temporal pattern of gaze (Noël & van der Kamp, 2012; Wood & Wilson, 2010). Noël and van der Kamp (2012) found that penalty takers who use a keeper-dependent strategy spend more time looking at the goalkeeper throughout the run-up and kick execution than penalty takers who use a keeper-independent strategy. The latter attend longer to the target area (in the preparatory phase before the run-up to the ball) and the ball (during the run-up and kick execution). These differences in gaze are correlated with the accuracy of the kick; the longer penalty takers look at the goalkeeper – rather than the ball – the closer the kick is to the goalkeeper (see also Bakker, Oudejans, Binsch, & van der Kamp, 2006; Wilson, Wood, & Vine, 2009; Wood & Wilson, 2010). Noël and van der Kamp (2012) claimed that the keeper-independent strategy is better than the keeper-dependent strategy, because more attention to the ball facilitates improved performance, while attention to the goalkeeper systematically biases aiming.

In sum, experimental findings suggest that the keeper-independent strategy is better than the keeper-dependent strategy. However, there is an important reservation: the presumed superiority of the keeper-independent strategy is based primarily on differences in kick accuracy in centimetres rather than the number of goals scored. If the kick is executed to the empty side of the goal (i.e., the goalkeeper dives in the opposite direction), then kicking accuracy is of little importance. Hence, the precise effectiveness of the two strategies is not known.

If the two penalty kick strategies involve dedicated perceptual motor behaviours, then identification of these processes can serve as a basis for the categorisation of kick strategies. In Experiment 1, participants watched clips of penalty kicks performed with either a keeper-independent or a keeper-dependent strategy. The participants rated each kick on several characteristics that we used to delineate which combination of characteristics permitted the identification of kick strategy. In Experiment 2, we evaluated the prevalence and efficacy of the two strategies by having observers rate these characteristics for penalty kicks taken during shoot-outs of the UEFA Championships and the FIFA World Cups between 1982 and 2012.

Experiment 1: demarcating penalty kick strategies

Experiment 1 investigated 12 candidate characteristics that are likely to differ between the keeper-independent and keeper-dependent strategies (Table I). We filmed skilled football players taking penalty kicks using both keeper-independent and keeper-dependent strategies. Participants rated the video clips on 12 candidate characteristics derived from previous research and anecdotal observations from experts in football (Memmert et al., 2013;

Table I. Items that the participants had to rate.

Item	Scale/options	Question
Attention	Attention – no attention to keeper	Does the player attend to the keeper's actions?
Deception	No deception – deception	Does the player try to deceive the keeper?
Run-up fluency	Stagnant – fluent run-up	How would you rate the fluency of the run-up?
Ball speed	Weak – forceful shot	How hard is the ball kicked?
Run-up length	Short – long run-up	How long is the run-up?
Last step	Short – long last step	How long is the last step of the run-up?
Preparation time	Short – long preparation	How long does it take the player to prepare for the penalty kick?
Gaze at goal area	Short – long gaze at goal area	How long does the player look in the direction of the goal/keeper?
Gaze at ball	Short – long gaze at ball	How long does the player look in the direction of the ball?
Kick accuracy	Not precise – precise	How would you rate the accuracy of the kick?
Confidence	Not confident – confident	How would you rate the player's confidence?
Kicking technique	Inside/instep/outside	Which kicking technique does the player use?

Savelsbergh, Versloot, Masters, & van der Kamp, 2010). One item assessed ball speed as Kuhn (1988) posited greater speeds for the keeper-independent strategy (van der Kamp, 2006). A second item assessed kicking technique as an instep drive results in more forceful shots than the inside-foot kick (Lees & Owens, 2011). Three items concerned the run-up (i.e., the length of the whole run-up, the length of the last step and the fluency of the run-up). Based on previous gaze measures (Noël & van der Kamp, 2012; Wood & Wilson, 2010), two items assessed looking at either the goal (including the goalkeeper) or the ball. As it is nearly impossible to distinguish looking behaviours of the goal and goalkeeper from video recordings, one item asked participants to rate penalty taker's attention to the goalkeeper (rather than looking at the goalkeeper). One item assessed kick accuracy, given the suggested relationship between looking at the ball and accuracy (Noël & van der Kamp, 2012). Two items examined preparation before the start of the run-up, as non-verbal behaviours (i.e., preparation time and confidence) could be associated with different kicking strategies (Furley, Dicks, & Memmert, 2012; Furley, Dicks, Stendtke, & Memmert, 2012). A final item based on expert opinions assessed deception, which we hypothesised was associated with the keeper-dependent strategy. The participants' ratings were investigated via logistic regression model to identify those items that predict penalty kick strategies.

Methods

Participants

With local ethics committee approval, 42 skilled football players (mean age = 25.1 years; SD = 7.5 years), who had been playing amateur or semi-professional football for 17 years (SD = 5.6 years), participated as observers.

Stimuli

Video footage of 84 penalty kicks was used as stimulus material. Twenty-one players and three goalkeepers from an under-19 professional German Bundesliga club assisted with stimuli creation during a single video-recording session. Kicks took place at an outdoor facility on artificial turf using a "FIFA approved" ball (size 5). Every player took four penalties, using the keeper-dependent and keeper-independent strategies on two occasions in a randomised order. Before every penalty kick, participants received instruction to use either a keeper-dependent strategy ("Try to direct the penalty kick to the empty side of the goal by anticipating the movement direction of the goalkeeper") or a keeper-independent strategy ("Choose a side in advance of the run-up and direct the penalty kick towards that side regardless of the goalkeeper's actions"). The players faced each of three goalkeepers at least once (also randomised). Goalkeepers were unaware of any of the instructions given to penalty takers and were required to save as many kicks as possible.

Each penalty kick was recorded by two cameras. One camera (Canon HG21) was placed behind the goal, while the second (Panasonic HX-WA10) was positioned 10 m behind and 8 m to the left of the penalty spot. Recordings started with penalty taker approaching the penalty spot to place the ball and ended 2 s after foot–ball contact. In accordance with the instructions provided, videos were later coded as either keeper-independent or keeper-dependent strategy.

During the experimental session, E-Prime 2.0 software (Psychology Software Tools, Pittsburg, PA) was used to present and rate the video clips of the penalty kicks on a 38-cm monitor. Items 1–11 were rated by marking a location on a continuous scale – visually presented as an 11-point Likert scale (Table I). The software transformed the ratings into a value (with 3 decimals) between 0 at the left pole of the scale and 1 at its right pole. The last item

(kicking technique) was categorical (instep, inside and outside). Participants pressed a keyboard button (i.e., 1 for instep, 2 for inside, or 3 for outside).

Procedure

Participants viewed 20 penalty kicks (10 from each kick strategy), which were randomly selected from the 42 clips and rated each kick on the 12 items (see Table I). Participants were naïve to the main purpose of the experiment (i.e., classifying penalty kick strategies) but were told that a central aim was to identify how to take a penalty kick successfully. After watching a penalty kick from both camera positions in succession (behind the penalty taker perspective first), the question (and scale) appeared on the screen. Participants could replay the video clip before rating an item. The experiment lasted approximately 1 h.

Data analysis

A multivariate analysis of variance (MANOVA) with penalty kick strategy (keeper-dependent, keeper-independent) as an independent variable and the ratings for items 1–11 as dependent variables compared measures. Chi-Square investigated the association between penalty kick strategy and item 12 (i.e., kicking technique). These analyses were followed by a logistic regression analysis with penalty kick strategy as the dependent variable and the ratings for item 1–12 as predictors. All analyses were done using SPSS 21.0 with alpha set at $P = 0.05$. We calculated Omega-Square and Cramer's V as effect size measures for analyses of variance, respectively, Chi-Square tests. To describe the strength of the association between variables of Chi-Square tests, we considered values of Cramer's V between 0.1 and 0.3 weak, values between 0.3 and 0.5 moderate and values above 0.5 strong (Cohen, 1988). Omega-Square values of 0.01 (weak), 0.06 (moderate) and 0.14 (strong) were used as evaluation criteria (Kirk, 1996).

Results

Differences between strategies

The MANOVA using Pillai's Trace indicated that penalty kick strategy affected participants' ratings ($V = 0.690$; $F(11, 72) = 14.5$, $P < 0.001$). Table II shows that strategies were rated differently for all but two of the non-categorical items (i.e., kicking accuracy and penalty taker's confidence). Fluency of the run-up, ball speed (both P's < 0.001), length of the run-up ($P < 0.05$), length of the last step and gaze directed to the ball (both P's < 0.01) were rated higher for the keeper-independent strategy, while attention to goalkeepers' actions, deception, preparation time and gaze directed at the goal (all P's < 0.03) were rated higher for the keeper-dependent strategy. Only differences between ratings for length of the run-up, preparation time and length of the last step couldn't be considered strong. In both strategies, penalty takers used the inside of the foot most frequently, but in the keeper-independent strategy, penalty takers contacted the ball with the instep more frequently than in the keeper-dependent strategy (χ^2 (2, $N = 840$) = 115.5, $P < 0.001$, $V = 0.31$, see Figure 1). This represents a moderate association between penalty kick strategy and kicking technique.

Predicting penalty kick strategy

The outcomes of the binary logistic regression analysis (backward LM method, Menard, 1995) with penalty kick strategy as the dependent variable and the 12 items as predictors are in Table III. Only three items predicted penalty kick strategy. Kicking technique had a negative B-value ($B = -1.13$), suggesting that use of the inside of the foot had a greater probability of predicting a keeper-dependent strategy. Attention to the goalkeeper ($B = 13.2$) and run-up fluency ($B = 20.8$) had positive B-values implying that less attention to the goalkeeper and a

Table II. Results of univariate analyses for the main effects of penalty taking strategy on the individual dependant variables.

Scale	*M* (SD) KD	*M* (SD) KI	*P*	ω^2
Attention – no attention to keeper	0.47 (0.14)	0.72 (0.12)	0.001	0.453
No deception – deception	0.59 (0.14)	0.35 (0.12)	0.001	0.425
Stagnant – fluent run-up	0.51 (0.09)	0.68 (0.10)	0.001	0.453
Weak – forceful shot	0.48 (0.10)	0.65 (0.10)	0.001	0.404
Short – long run-up	0.49 (0.08)	0.51 (0.08)	0.048	0.010
Short – long last step	0.49 (0.08)	0.53 (0.05)	0.009	0.068
Short – long preparation	0.48 (0.09)	0.43 (0.09)	0.025	0.047
Short – long gaze at goal area	0.58 (0.15)	0.36 (0.15)	0.001	0.336
Short – long gaze at ball	0.47 (0.14)	0.64 (0.17)	0.001	0.241
Not precise – precise	0.62 (0.12)	0.60 (0.13)	0.523	0.007
Not confident – confident	0.64 (0.11)	0.67 (0.10)	0.250	0.004

Note: Scales range from 0 to 1.

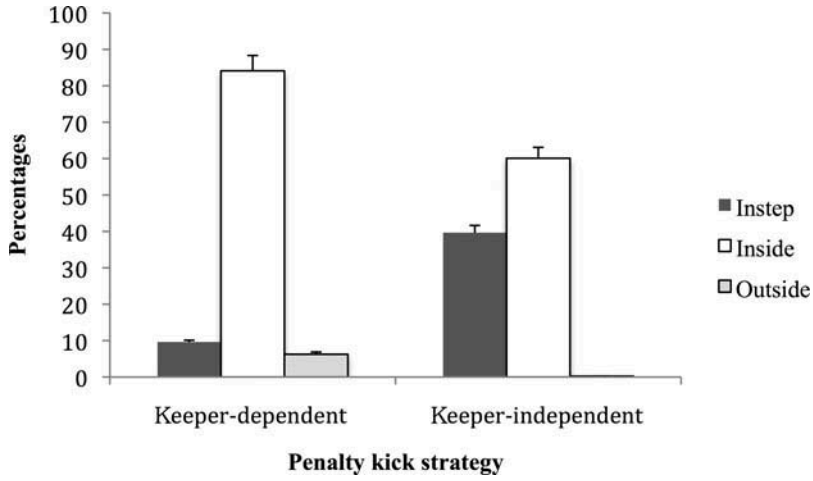

Figure 1. Kicking technique as a function of penalty taking strategy.

Table III. Predictors of penalty kick strategy in Experiment 1.

	Penalty kick strategies		
Variable	*B*	*SE*	*Sig.*
Constant	−11.67	7.93	
Attention	13.15	5.1	0.01
Run-up fluency	20.98	9.75	0.033
Kicking technique	−1.13	0.47	0.016

Note: $R^2 = 0.886$ *(Nagelkerke). Model* $\chi^2(6) = 91.7$, $P < 0.001$.

more fluent run-up were associated with a keeper-independent strategy. The model's cut-off point was 0.5. Values below 0.5 indicated a keeper-dependent strategy while values equal to and above 0.5 indicated a keeper-independent strategy. The model had a high prediction rate (91.7%) and model fit (R^2 = 0.886). Figure 2 illustrates that the model clearly identified two clusters of penalty kicks. The left cluster indicates a high likelihood of constituting keeper-independent strategy and the right cluster indicates a low probability of constituting a keeper-independent strategy (and thus a high probability for a keeper-dependent strategy). Only a small minority of penalty kicks were between clusters. Finally, the predictors showed no signs of multicolinearity (i.e., variance inflation factor values of all predictors were between 1.1 and 3.3, permitting the estimation of *B*-values), and there was linearity between each continuous predictor and the logit of the criterion.

Discussion

Experiment 1 showed that ratings for 10 of the 12 candidate variables differed between the keeper-independent and keeper-dependent penalty kick strategies. A subsequent logistic regression model narrowed these variables down to three. Attention to the goalkeeper, run-up fluency and kicking technique delineated the two penalty kick strategies with a prediction rate of 91.7%. Because the model revealed two separate clusters of penalty kick, the strategy selected can be identified with high probability. However, it is possible that the high prediction accuracy was inflated because penalty takers were instructed to use either penalty strategy. In competition, penalty kicks are probably a fusion of the two strategies.

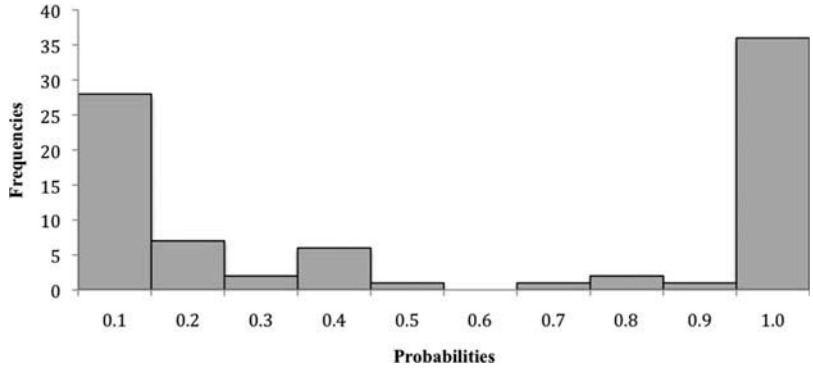

Figure 2. Predicted probabilities of membership for keeper-independent strategy.

Ratings for attention and looking behaviours confirmed previous findings (Noël & van der Kamp, 2012; Wilson et al., 2009). Penalty takers were judged to attend less to the goalkeeper in the keeper-dependent strategy than the keeper-independent strategy. This indicates that the adoption of a keeper-dependent strategy necessitated the continuous monitoring of the goalkeeper's action. In contrast, the keeper-independent strategy did not require such monitoring and so allowed attention to the ball to support foot–ball contact. This suggestion is consistent with ratings for looking at the goalkeeper/goal (greater for the keeper-dependent strategy) and the ball (greater for the keeper-independent strategy). However, only attention to the goalkeeper was a contributor to the model, while the ratings for looking at the goalkeeper/goal and at the ball did not enhance prediction by the model (i.e., the other variables that relate to gaze or attention did not explain any additional variance). This might be because attention to the goalkeeper was the only item that restricted the observer's rating to the goalkeeper.

Ratings for all items for the run-up (i.e., its fluency and length and the length of the last step) differed between strategies. For penalty kicks with the keeper-independent strategy, the run-up was rated as more fluent, and the total run-up and last step distance were rated as longer than for kicks with the keeper-dependent strategy. However, differences regarding length of the whole run-up and the last step were small. Fluency most strongly discriminated between the two strategies and, hence, entered as a predictor to the regression model. The difference in fluency is probably a consequence of penalty takers who use a keeper-dependent strategy to increase time at the end of the run-up by waiting for the goalkeeper to commit to one side of the goal (van der Kamp, 2006). Mario Balotelli, the striker of AC Milan, provides a very clear example of the latter strategy.

The instep kick occurred more often for the keeper-independent than keeper-dependent strategy. Instep drives produce greater ball speed than the inside kick (Lees & Owens, 2011). Possibly, this is why kicking technique rather than ball speed, which was also rated higher for the keeper-independent strategy, contributed to the regression model. Importantly, the higher rating for ball speed in the keeper-independent strategy supported Kuhn (1988). However, when kicking technique was included in the current logistic model, the prediction was greater than for ball speed alone. A logistic regression model with ratings of ball speed as its sole predictor had a prediction rate of only 77% (rather than the 91.7% prediction of the current model).

Ratings for preparation time and deception were greater in the keeper-dependent strategy than in the keeper-independent strategy, although neither contributed to the logistic regression model. Penalty takers were judged to take more time to prepare before the run-up and are more likely to try to deceive the goalkeeper than when they used a keeper-dependent strategy. However, these differences did not increase the variance explained by the model. Whereas ratings for the use of deception differed strongly, differences in preparation time were probably too small to differentiate strategies. Finally, judgments of strikers' confidence and kick accuracy did not differ between penalty kick strategies. This finding is notable because evidence supporting the presumed success of the keeper-independent strategy is based primarily on differences in kick accuracy (in cm). While this finding raises the issue of whether the keeper-independent strategy is indeed superior to the keeper-dependent strategy, it is possible that the video clips could not identify small differences in accuracy. In Experiment 2, we used the current logistic regression model to examine the prevalence of strategies in penalty shoot-outs during international-standard competitions and establish their respective success rates.

Experiment 2: prevalence and efficacy of penalty kick strategies

Kuhn (1988) reported that the keeper-dependent strategy constituted approximately three-quarters of penalty kicks. This was based on the analysis of 66 penalty kicks. In Experiment 2, we analysed a much larger sample of penalty kicks from international-standard competitions. Rather than limit the classification to ball speed, as Kuhn did, we use the method developed in Experiment 1. We extended examination of the prevalence of the two strategies in international-standard competitions. We also examined the success of the two strategies. Previous findings from mainly skilled amateurs or semi-professionals, suggested that the keeper-independent strategy was more effective, particularly for kick accuracy (e.g., Noël & van der Kamp, 2012; van der Kamp, 2006; Wood & Wilson, 2010). Penalty kick accuracy does not necessarily result in more goals (cf. Noël & van der Kamp, 2012), as a kick to the opposite side of goal that a goalkeeper dives does not have to be accurate to be successful.

Method

Participants

With local ethics committee approval, men football players (n = 43, mean age = 29 years, SD = 7.1), who played amateur or semi-professional standard

football for 21.6 years (SD = 6.3) participated as observers.

Stimuli

All penalty kicks from penalty shoot-outs during FIFA World Cups (1986–2010) and UEFA European Football Championships (1984–2012) were used as stimuli, amounting to 322 penalty kicks. The clips of the penalty kicks were obtained from various sources (e.g., Youtube.com and a private collection of TV broadcasts). The camera perspective varied among recordings, but always resembled one of the two perspectives used in Experiment 1 (i.e., from behind the goal or the penalty taker). The penalty kicks were presented on a 15-inch monitor using E-Prime 2.0 software (Psychology Software Tools, Pittsburg, PA, USA).

Procedure

Participants rated 30 penalty kicks on the same 12 items as in Experiment 1. The penalty kicks were randomly selected from the pool of video recordings. Every penalty kick was rated at least four times. The rest of the procedure and design was identical to Experiment 1. Logistic regression categorised penalty kicks as either keeper-dependent or keeper-independent before calculating the prevalence and success rate of the two strategies.

The intra-class correlation for probability scores of the penalty kicks was moderate (ICC = 0.70). Four observers rated clips, but the particular set of observers differed between clips. Hence, we used a second way to assess observer reliability. Two additional observers, both football coaches, rated each penalty kick for the three variables of the regression model (i.e., attention for the goalkeeper, run-up fluency and kicking technique). Based on these ratings, the penalty kicks were classified as either keeper-independent or keeper-dependent. The inter-observer agreement was high (Cohen's Kappa = 0.79). Hence, we conclude that the model reliably classified penalty kick strategy.

Results and discussion

The three-predictor logistic regression model derived from Experiment 1 classified 82% of penalty kicks as keeper-independent, whereas the remaining 18% were classified as keeper-dependent. The distribution of mean probabilities for the respective penalties showed that the two penalty kick strategies were clearly distinguishable (Figure 3). The logistic regression model classified 19 of the 322 penalties (i.e., 6%) ambiguously, with probabilities ranging between 0.3 and 0.7. These kicks had a likelihood of less than 70% of being classified correctly (Figure 3). Omitting these penalties led to 86% of kicks being classified as keeper-independent and 14% as keeper-dependent. This contrasts with Kuhn's (1988) observations, which indicated that most penalty kicks used a keeper-dependent strategy. Using a model that includes ratings only of ball speed contradicts Kuhn's findings: 60% of kicks used the keeper-independent strategy while the remaining 40% used a keeper-dependent strategy.

The prevalence of the penalty kick strategies could have been mediated by personal or situational factors, including a player's skill, experience of taking penalties, fatigue, anxiety, or importance of the kick. To examine whether the importance of the penalty kick for match outcome (presumably enhancing a player's anxiety) influences penalty kick strategy, we compared kicks for which a penalty taker had to score to prevent his team from losing the penalty shoot-out ($N = 12$) and kicks for which a penalty taker could win the penalty shoot-out ($N = 25$) with non-decisive penalty kicks ($N = 285$). Prevalence for keeper-independent and keeper-dependent strategies among the

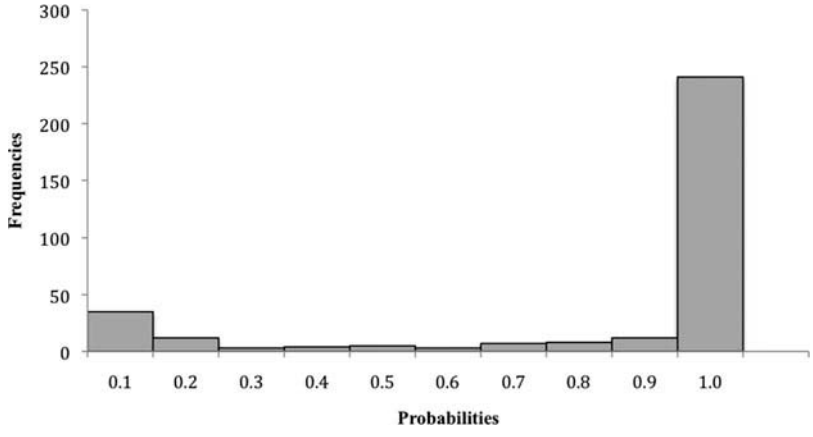

Figure 3. Distribution of probabilities: does a penalty kick constitute keeper-independent or keeper-dependent strategy?

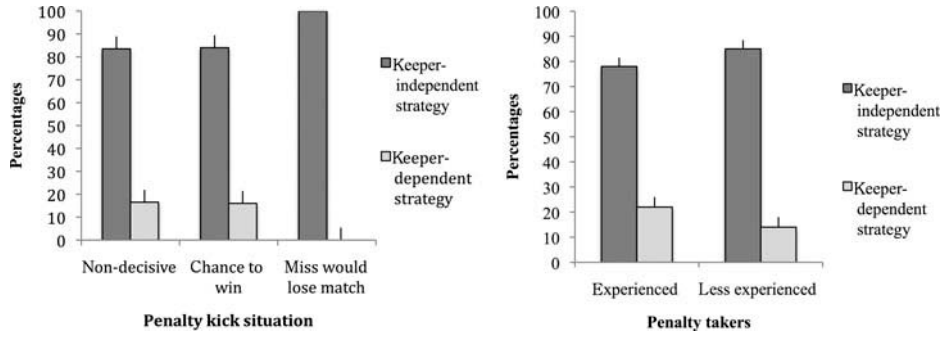

Figure 4. Percentages of penalty kick strategies used in relation to the importance of the penalty kick for the match outcome and the penalty takers' experience.

decisive and non-decisive kicks did not differ, χ^2 (1, N = 322) = 0.793; $P > 0.35$, two-tailed. In addition, as Figure 4 illustrates, when penalty takers had a chance to win, 84% of the kicks were keeper-independent while all penalties were keeper-independent when a miss would lose the match. In short, keeper-independent strategy remained dominant irrespective of the importance of the penalty kick.

We also explored whether penalty kick strategy changed with penalty kick experience (Figure 4). Players that had previously taken more than two penalties during shoot-outs in continental championships and FIFA World Cups (N = 40) used keeper-independent strategy about as often as players with less experience (N = 282), χ^2 (1, N = 322) = 1.52; $P > 0.2$, two-tailed (78% and 85%, respectively). We wish to stress the exploratory nature of this analysis though. The current measure of experience was limited to the penalty shoot-outs for the current data set. Penalties taken within regular match times and, perhaps more importantly, during national and international club matches were not considered. Tests with age and number of international appearances produced a similar pattern.

Success rates for the keeper-independent (i.e., 73.8% of kicks converted) and the keeper-dependent strategy (70.6%) did not differ, χ^2 (1, N = 322) = 0.46; $P > 0.8$, two-tailed (Figure 5). Studies suggest that the keeper-independent strategy improves accuracy of kicks. Our results suggest that both the strategies are equally effective. Importantly, this does not imply that success is independent of an individual player's choice for a strategy. Individual differences such as skill or resilience to anxiety could still make the keeper-independent or keeper-dependent strategy more suitable and effective.

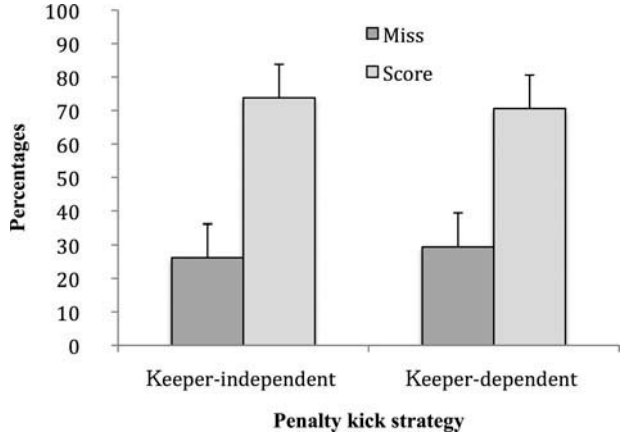

Figure 5. Number of penalty kicks missed and converted in relation to penalty kick strategies used.

General discussion

This study delineated characteristics that distinguish penalty kick strategies and developed a method to identify keeper-independent and keeper-dependent strategies in competition. Penalty shoot-outs in UEFA championships and FIFA World Cups between 1982 and 2012 were analysed to determine the efficacy of the two strategies. Experiment 1 indicated that keeper-independent and keeper-dependent strategies differed in several dimensions, confirming that they are separate strategies. The strategies differed in the run-up, looking behaviour, kicking technique, preparation time and use of deception. More importantly, our analyses indicated that keeper-independent and keeper-dependent strategies can be distinguished with a prediction accuracy of over 90% using a logistic regression model with observer ratings only for attention for the goalkeeper's behaviour, run-up fluency and kicking technique. Earlier proposed characteristics such as ball speed did not increase the accuracy of the model.

Limitations of the model need to be acknowledged as these help highlight important areas for future work. In Experiment 1, players were instructed to use only a keeper-independent or a keeper-dependent strategy, with the implicit assumption that penalty taking is an "either-or" issue. In competition, however, the adoption of the two strategies can be considered as a continuum rather than being dichotomous. For

example, penalty kickers might choose to take the goalkeepers' action into account, until they are one or two steps away from the ball. Consequently, kicks will be fully keeper-dependent only when a goalkeeper moves early enough to allow penalty takers to try to direct the ball to the empty side of the goal (van der Kamp, 2006). If the goalkeeper does not start to move until close to ball contact, penalty takers can retain the side that they had chosen. The current model and procedures might not have been sensitive enough to identify these small differences. Future work needs to address how these and other factors affect the validity of the current model.

Contrary to Kuhn's (1988) suggestions, Experiment 2 showed that most of penalty kicks (i.e., 78%–85%) were keeper-independent. Moreover, and again in contrast to earlier studies (e.g., van der Kamp, 2006, 2011), there was no evidence that either strategy was superior to the other. The logistic regression identified the keeper-independent strategy is used more frequently in competition. The keeper-independent strategy could allow players to increase their (perceived) control of the situation through the use of pre-performance routines (e.g., Jackson & Baker, 2001; Wood & Wilson, 2010). This might be especially advantageous for less experienced penalty takers – in shoot-outs often non-specialist take penalties as well. Hence, although both strategies have similar success rates, the keeper-independent strategy might offer additional advantages that could contribute to its high prevalence in competition.

The distributions of keeper-independent and keeper-dependent strategies might also point to penalty takers adopting a mixed strategy, during which they interchange the two strategies from one penalty kick to the next. Using principles from game theory (Chiappori, Levitt, & Groseclose, 2002; Palacios-Huerta, 2003) revealed that penalty takers do not consistently choose to kick to a preferred side of the goal. Using an invariable strategy would make it easier for goalkeepers to predict kick direction. Therefore, rather than adopting a set strategy, penalty takers should interchange keeper-independent and keeper-dependent strategies so that the chances of scoring are maximised for both strategies (even if one strategy is more effective than the other). The current pattern of findings, with the keeper-independent strategy being predominant over the keeper-dependent strategy and with both strategies being equally successful, is compatible to predictions from game theory that players are likely to benefit from adopting a mixed strategy.

The findings from the current study have implications for performance analysts and/or coaches who seek to identify penalty takers' likely strategy. A goalkeeper could benefit from knowing both a penalty taker's preferred kick strategy and direction. For example, Hans Jörg Butt, a German professional goalkeeper who was successful at saving (opposing players' success rate was less than 70%) and kicking penalty kicks (26 converted penalty kicks), accounted for takers' kicking strategy (Leininger & Ockenfels, 2008). Knowing that the penalty taker prefers a keeper-dependent strategy allows a goalkeeper to wait longer before choosing a side of the goal, thereby improve his or her chances of making saves (Furley, Dicks, Stendtke, et al., 2012). A goalkeeper, who waits before taking action, reduces the time the penalty taker has available to control kick placement to the empty side of goal (van der Kamp, 2006, 2011), especially when under pressure (Navarro et al., 2012). Additionally, we would advice a goalkeeper (especially a less agile one), who knows that a penalty taker prefers to use a keeper-independent strategy, to dive early to that side of the goal that is believed to be the penalty taker's preferred side (Navia, van der Kamp, & Ruiz, 2013; Palacios-Huerta, 2003). These claims should be the target for future research.

Even when a goalkeeper has no knowledge of the kicker's preferred strategy, the current findings can be of help. A goalkeeper could try to identify a penalty kick strategy by focusing on the fluency of (the early parts of) the run-up and the kicker's gaze. A penalty taker who tends to slow down, uses shorter strides and looks frequently at the goalkeeper is likely to use a keeper-dependent strategy. It is advisable for the goalkeeper to wait longer before starting to dive. By contrast, if a penalty taker runs up steadily, while largely ignoring the goalkeeper, a keeper-independent strategy is more likely. The goalkeeper is then advised to dive early to the kicker's natural side (Palacios-Huerta, 2003).

To conclude, the current study is the first to develop a validated method that distinguished penalty kick strategies. The findings suggest that the keeper-independent strategy is prevalent in international-standard competition, although there is comparable success between the two respective strategies. This technique advances previous research. In addition, the method can easily be used in practice, allowing goalkeepers to improve adjustment of their strategy to counter that of penalty taker's.

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