

Visual search, anticipation and expertise in soccer goalkeepers

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We used a novel methodological approach to examine skill-based differences in anticipation and visual search behaviour during the penalty kick in soccer. Expert and novice goalkeepers were required to move a joystick in response to penalty kicks presented on film. The proportion of penalties saved was assessed, as well as the frequency and time of initiation of joystick corrections. Visual search behaviour was examined using an eye movement registration system. Expert goalkeepers were generally more accurate in predicting the direction of the penalty kick, waited longer before initiating a response and made fewer corrective movements with the joystick. The expert goalkeepers used a more efficient search strategy involving fewer fixations of longer duration to less disparate areas of the display. The novices spent longer fixating on the trunk, arms and hips, whereas the experts found the kicking leg, non-kicking leg and ball areas to be more informative, particularly as the moment of foot–ball contact approached. No differences in visual search behaviour were observed between successful and unsuccessful penalties. The results have implications for improving anticipation skill at penalty kicks.

Keywords: penalty kicks, perceptual skill, performance.

Introduction

Expert soccer goalkeepers demonstrate highly skilled and well coordinated behaviour when diving or jumping to catch the ball. Such skilled behaviour requires many years of practice (Ericsson *et al.*, 1993), allied to a considerable amount of ability (Singer and Janelle, 1999). It is now accepted that successful performance in such sports requires skill in perception as well as the efficient and accurate execution of movement patterns (see Williams *et al.*, 1999). The awareness that skilled perception precedes appropriate action has led researchers to examine its role in sport performance. For example, it has been demonstrated that experts are better than novices in using advance visual cues to guide their anticipatory responses (Abernethy, 1987; Williams and Burwitz, 1993).

A player's ability to use advance postural cues is particularly important in fast ball sports where the speed of play and ball velocity dictate that decisions must often be made in advance of the action. High-speed film analysis indicates that players who react to the ball, as opposed to anticipating its intended destination, are unlikely to be successful (Glencross and Cibich, 1977). The temporal occlusion paradigm has been used to examine anticipatory cue usage in sport. In this approach, participants are presented with filmed sequences that are representative of their customary view of the action. These film clips are selectively edited to provide a varying extent of advance and ball flight information, with participants being required to predict the end result of the sequence being observed. The expert performer's superiority over the novice has been demonstrated in a range of sports including soccer, with these differences being more pronounced at the earliest (pre-event) occlusion conditions (for a detailed review, see Williams *et al.*, 1999; Starkes *et al.*, 2001).

In one such study, Williams and Burwitz (1993) required expert and novice goalkeepers to observe

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filmed sequences of five different players taking penalty kicks. The participants viewed the player's preparatory stance, approach run and kicking action up to the point of occlusion and were required to indicate, using a pen and paper response, the corner of the goal in which the ball would be directed. Four occlusion periods were used: 120 and 40 ms before the player kicked the ball, at impact and 40 ms after impact. The expert goalkeepers performed better than their novice counterparts under the pre-impact viewing conditions only (see also McMorris *et al.*, 1993; McMorris and Colenso, 1996). Performance under the earliest occlusion condition was significantly better than chance (i.e. 25% success rate) for both experts (51%) and novices (39%), signifying that players are able to effectively use information available before ball impact in the penalty kick. Most errors (62%) were associated with incorrect judgements about height; only 26% of errors were due to incorrect predictions about which side of the goal the ball was placed (see also Salmela and Fiorito, 1979; McMorris *et al.*, 1993).

Although researchers have tried to identify the important sources of information used by expert goalkeepers during the penalty kick, the findings are somewhat contradictory (for a detailed review, see Williams, 2000). The position of the hips, kicking leg and trunk just before and during contact is presumed to be important (e.g. Tyldesley *et al.*, 1982; Williams and Burwitz, 1993), while others argue that the orientation of the non-kicking foot is key (e.g. Franks and Hanvey, 1997). However, researchers have typically relied on verbal reports or event occlusion techniques and few attempts have been made to record goalkeepers' visual behaviours using eye movement registration techniques (for a detailed discussion and review of methodologies, see Williams *et al.*, 1999). Most of those involved in eye movement research in sport have attempted to identify differences in visual behaviour as a function of age, skill or experience. Typically, researchers have neglected to examine whether performers use different visual search patterns during successful and unsuccessful attempts on the same task (for an exception, see Helsen and Starkes, 1999). The customary approach has been to collapse data from successful and unsuccessful trials to identify consistent differences in visual search strategies between groups. An interesting question is whether there are subtle differences in visual search behaviour across successful and unsuccessful trials that may help identify the determinants of successful performance.

In most previous studies, static slide displays have been used (e.g. Tyldesley *et al.*, 1982) and participants were required to perform discrete rather than continuous actions in response to these stimuli (e.g. Williams and Burwitz, 1993; Franks and Hanvey, 1997). The information contained in static displays

has been shown to be less sensitive and discriminating than that provided by dynamic film or live models (Bourgeaud and Abernethy, 1987). In particular, the relative motions presented in dynamic action sequences may be crucial to anticipation in sport (Abernethy *et al.*, 2001; Ward *et al.*, 2002). Similarly, the typical response requirements have varied from pressing a button (Tyldesley *et al.*, 1982; Neumaier *et al.*, 1987; Franks and Hanvey, 1997) to written (McMorris *et al.*, 1993; Williams and Burwitz, 1993; McMorris and Colenso, 1996) or verbal responses (Salmela and Fiorito, 1979). In such circumstances, corrections or modifications to the response are not possible as the display unfolds, unlike the real performance setting where players have the opportunity to modify their actions continuously. The ability to make ongoing corrections has gained increasing importance since the recent rule change that allows goalkeepers to move across the goal line before the ball is struck by the penalty taker. In line with this limitation, researchers have relied heavily on the temporal occlusion paradigm to assess anticipatory performance in the penalty kick (see Keller *et al.*, 1979; Salmela and Fiorito, 1979; Neumaier *et al.*, 1987; McMorris *et al.*, 1993; McMorris and Colenso, 1996). In this approach, the time constraints for information selection and action are determined externally by the experimenter rather than by the performer, as is normally the case in the sporting arena (Williams *et al.*, 1999).

The present study embraces new technology in an attempt to determine key differences in visual search behaviour and anticipatory performance between expert and novice soccer goalkeepers. The study was undertaken from a perception-action perspective, where information is presumed to evolve over time, and where action is continuously coupled to the perceptual information presented (see Savelsbergh and Van der Kamp, 2000). In this innovative paradigm, visual information is picked up in a continuous rather than discrete fashion and the response is not measured by a button press, but by means of a joystick linked to a potentiometer to ensure continuous data sampling. This procedure allows corrections to be made to the response in an ongoing manner as the flow of information changes across early and late periods in the penalty kick. In keeping with previous research, we predicted that, as a result of their greater experience and more refined task-specific knowledge structures (see Williams, 2000), expert goalkeepers would demonstrate superior anticipation and more efficient and effective visual search strategies than their novice counterparts. A secondary aim was to determine whether goalkeepers use different visual search behaviours on successful versus unsuccessful penalties. In light of the limited research on the visual behaviour of soccer goalkeepers, and the conflicting

nature of current findings, it was not possible to predict the exact nature of the expected differences in visual search strategies across skill groups or between successful and unsuccessful penalties.

Methods

Participants

Fourteen players provided informed consent before participating in the study. The expert group consisted of seven soccer goalkeepers aged 29.9 ± 7.1 years (mean $\pm s$) who had played semi-professional football (second division of the National League) in the Netherlands for a minimum of 10 years. The novices included seven goalkeepers aged 21.3 ± 1.4 years who had played soccer less frequently for recreation.

Test film

The test film was produced in conjunction with PSV Eindhoven Football Club. Ten professional youth players aged 18.9 ± 1.5 years were filmed from the goalkeeper's perspective taking penalty kicks. The film clips were recorded using a digital video camera (Canon XM 1) positioned in the middle of the goal at a height of 1.77 m.

A sailcloth (2.42×1.50 m) was hung from a regulation crossbar to indicate the area to which the players had to shoot. Six different target areas (0.81×1.50 m) were painted on the sailcloth, as highlighted in Fig. 1. The players were told to try and disguise the intended destination of the penalty kick, as they would in normal competition. Each film clip included the penalty taker's approach to the ball, their actions before and during ball contact, and the first portion of ball flight. Two penalties were recorded in each target location for every player, providing a total of 120 trials. A microphone was attached to the sailcloth to indicate the moment at

which the ball crossed the goal line; a second microphone was positioned near the penalty spot to record the moment of ball-foot contact. These two temporal measures were used to calculate the flight time and velocity for each penalty kick. The average ball flight time was 648 ms, whereas the mean ball velocity was $16.8 \text{ m} \cdot \text{s}^{-1}$.

Apparatus

The film clips were back-projected (EIK CC-7000), using a reflective surface to increase image size, onto a large screen (2.29×2.27 m) positioned 3.45 m from the participant. The experimental layout is represented graphically in Fig. 2. The image of the penalty taker subtended a visual angle of approximately 8° at foot-ball impact, thereby closely simulating the real image size and distance between the goalkeeper and the penalty spot.

The response movements performed by the participants were recorded using a hand-held joystick. The joystick (Dual Axis Farnell M11Q61P) was positioned at waist height just in front of the participant. The joystick signal was amplified and stored on computer by means of LABVIEW (version 5.1). The film clip and the joystick were synchronized by means of a 5 V signal that marked the start and end of the film clip.

Visual search behaviours were recorded using an eye-head integration system that included an Applied Science Laboratories (ASL) 4000SU eye-tracker and an Ascension Technologies magnetic head-tracker (model: 6DFOB). The eye-head integration system is a video-based monocular system that measures eye line of gaze using head-mounted optics. The system works by collecting three pieces of information: displacement between the left pupil and corneal reflex (reflection of the light source from the surface of the cornea), position of eye in head, and position and orientation of head in space. The relative position of these features is used to

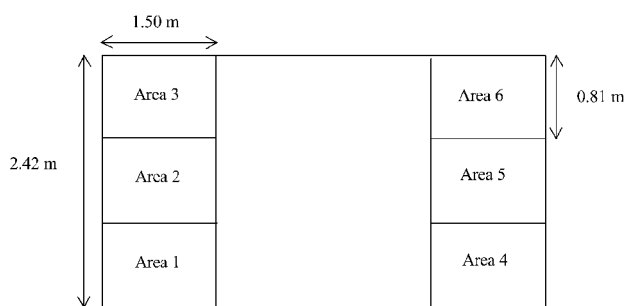


Fig. 1. The goal divided into six areas for placement of penalties and joystick movements.

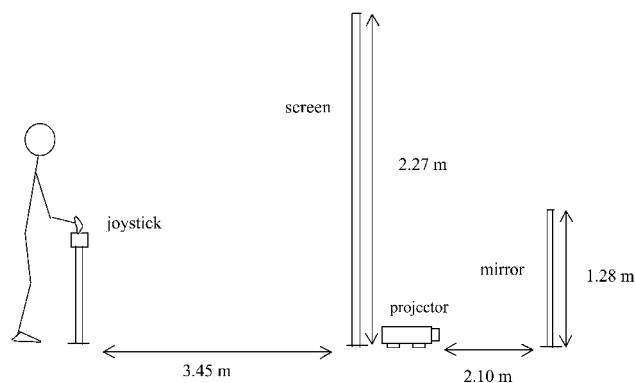


Fig. 2. A side view of the experimental set-up.

compute visual point of gaze with respect to a pre-calibrated nine-point grid projected onto the scene plane. A simple eye calibration was performed to verify point of gaze before each participant was tested. The calibration was checked following each block of 10 trials. The data were superimposed onto the scene in the form of a positional cursor to highlight visual point of gaze. This image was then stored using a video recorder for further analysis. The data were subjected to a frame-by-frame analysis using a PAL standard video recorder (Panasonic AG7330) at 50 Hz. The accuracy of the system was $\pm 1^\circ$ of visual angle. System precision (i.e. the amount of instrument noise in the eye position measure when the eye is perfectly stationary) was better than 0.5° in both the horizontal and the vertical direction.

Procedure

The participants were positioned behind the joystick. They had to anticipate the direction of each penalty kick quickly and accurately by moving the joystick as if to intercept the ball. If the joystick was positioned in the correct location at the moment the ball crossed the goal line, the penalty was judged to be a successful save. The participants were allowed to use the joystick to make corrections to their initial decision as the penalty kick evolved. No feedback was given as to their performance on each trial. Before the penalties were presented, a non-task-specific test was undertaken to determine whether there were 'baseline' differences in simple reaction time between the two groups. Instead of a penalty clip, an asterisk was presented at one of six possible locations and the participant had to move the joystick as quickly as possible to the correct position. An asterisk was presented at random at each location four times, providing a total of 24 test trials. These trials helped the participants to familiarize themselves with the movements of the joystick.

After the reaction time test, five practice trials were performed using the penalty clips. After familiarization and habituation, 30 film clips were presented; five penalties in each location. These film clips were chosen from the original sample of 120 trials by a panel of three experienced soccer coaches as being representative of typical penalty kicks. Half of the film clips involved a left-footed penalty taker; the remaining trials involved right-footed players. The locations of the penalties were completely randomized, but kept in the same order for each participant.

Dependent variables and analysis

Anticipation test. The following measures were recorded from the anticipation test:

- *Penalties saved.* The percentage of trials in which the joystick was positioned at the correct location at the moment the ball crossed the goal line.
- *Correct side.* The percentage of trials in which the joystick was positioned in the correct side (i.e. right or left judgement) at the moment the ball crossed the goal line.
- *Correct height.* The percentage of trials in which the joystick was positioned at the correct height (i.e. high or low judgement) at the moment the ball crossed the goal line.
- *Proportion of corrections.* The percentage of trials in which corrective movements of the joystick were made before the ball passed the goal line.
- *Time of initiation of joystick movement.* The time when the participant began to move the joystick relative to foot-ball contact by the penalty taker.
- *Reaction time.* The time from the presentation of the asterisk stimulus in the reaction time test to the initiation of joystick movement. This period was intended as a 'baseline' measure of reaction time.

Each dependent measure was analysed separately using a one-way analysis of variance in which group (expert, novice) was the between-participants factor.

Visual search data. The following visual search measures were obtained:

- *Search rate.* This measure included the mean number of visual fixations, the mean number of areas fixated and the mean fixation duration per trial. A fixation was defined as the time when the eye remained stationary within 1.5° of movement tolerance for a period equal to, or greater than, 120 ms or six video frames (see Williams *et al.*, 1994).
- *Percentage viewing time.* Percentage viewing time referred to the amount of time participants spent fixating various areas of the display when trying to anticipate ball direction. The screen was divided into eight fixation locations: head, shoulders, arms, trunk, hips, kicking leg, non-kicking leg and ball. A further 'unclassified' category was used for data that did not fall into one of these classifications. To determine whether the areas fixated varied across each stage of the penalty kick, the data were grouped into four temporal periods working backwards from a point 200 ms after ball contact by the penalty taker. These periods were 0–500 ms (including foot-ball contact), 501–1000 ms, 1001–1500 ms and 1500+ ms (including a portion of the run up).

Each search rate measure was analysed separately using a two-way analysis of variance with group as the between-participants factor and accuracy (successful,

unsuccessful) as the within-participants factor. The percentage viewing time data were analysed using a factorial analysis of variance in which fixation location (head, trunk, shoulders, arms, hips, kicking leg, non-kicking leg, ball and 'unclassified'), time (0–500, 501–1000, 1001–1500 and 1500+ ms) and accuracy were within-participants factors and group was a between-participants factor.

All data expressed as a percentage were subjected to arcsine transformation. However, a minimal effect was observed on the distribution of the data and the respective F -values were unchanged. Therefore, the results and subsequent analyses are presented with respect to the original data.

Results

Anticipation test

The mean group performance scores across the dependent variables are presented in Table 1. There were no significant differences between the two groups of goalkeepers in the percentage of penalties saved ($F_{1,12} = 4.01$, $P = 0.06$). However, the differences in accuracy between the two groups (experts *vs* novices: 35.7 *vs* 25.9%) did approach significance and this trend is highlighted by the fact that the expert goalkeepers were significantly more accurate in predicting penalty kick height ($F_{1,12} = 4.79$, $P < 0.05$) and side ($F_{1,12} = 5.21$, $P < 0.05$). The expert goalkeepers also made corrective movements of the joystick on fewer trials ($F_{1,12} = 4.98$, $P < 0.05$) and started these corrective movements nearer to foot-ball contact (i.e. later) than the novice goalkeepers ($F_{1,12} = 6.87$, $P < 0.05$). There were no differences in simple reaction time between the two groups of participants ($P > 0.05$).

Visual search data

Search rate. The mean group scores for each variable are presented in Table 2. There was a significant group main effect for fixation duration ($F_{1,12} = 11.1$, $P < 0.01$), number of fixations ($F_{1,12} = 27.6$, $P < 0.01$) and the number of areas fixated per trial ($F_{1,12} = 5.71$, $P < 0.05$). The expert goalkeepers used a less exhaustive search strategy involving fewer fixations (2.9 *vs* 4.0) of longer duration (585 *vs* 430 ms) than their novice counterparts. The expert goalkeepers also fixated on significantly fewer areas per trial than novices (2.6 *vs* 3.1). There were no differences on any of the search rate variables between the successful and unsuccessful trials.

Percentage viewing time. An initial Mauchly's sphericity test revealed a violation of the sphericity assumption for

Table 1. The dependent measures recorded on the anticipation test across groups (mean \pm s)

	Experts	Novices
Penalties stopped (%)	35.7 \pm 11.8	25.9 \pm 10.8
Correct height (%)	42.6 \pm 8.9	32.6 \pm 8.2
Correct side (%)	83.8 \pm 11.8	71.4 \pm 8.2
Proportion of corrections (%)	26.3 \pm 4.9	38.5 \pm 15.3
Time of initiation of joystick movement (ms)	296 \pm 46.6	480 \pm 29.2
Reaction time (ms)	258 \pm 33.1	237 \pm 46.4

Table 2. Fixation duration, number of fixations and number of fixation locations across groups (mean \pm s)

	Experts	Novices
Fixation duration (ms)	585 \pm 108	430 \pm 75.9
Number of fixation locations	2.6 \pm 0.4	3.1 \pm 0.5
Number of fixations	2.9 \pm 0.4	4.0 \pm 0.5

repeated-measures analysis of variance on the time main effect ($\chi^2_5 = 32.3$, $\epsilon = 0.39$, $P < 0.01$). The time main effect was therefore analysed using a type of multivariate analysis of variance, as recommended by Schutz and Gessaroli (1987). The analyses indicated a significant difference across time ($F_{3,9} = 41.3$, $P < 0.01$). A significant main effect was also observed for location ($F_{8,88} = 3.40$, $P < 0.01$), as well as for the time \times location ($F_{24,264} = 3.56$, $P < 0.01$) and the time \times location \times group interactions ($F_{24,264} = 2.29$, $P < 0.01$). These differences are presented graphically in Fig. 3. Figure 3 indicates that as the penalty kick evolved the novices spent progressively more time fixating on the trunk, arm and hip regions than the expert goalkeepers. In contrast, as the penalty kick unfolded the experts appeared to extract more information than novices from the kicking leg, non-kicking leg and ball regions. The experts also spent more time fixating on the head early in the action sequence than the novices, who fixated for longer on 'unclassified' regions early on. There were no differences in areas fixated between successful and unsuccessful trials ($P > 0.05$).

Discussion

In this study, we used an innovative methodological approach to examine differences in anticipation and visual search behaviour between expert and novice goalkeepers at the penalty kick in soccer. We predicted that experts would demonstrate superior anticipation and more refined and selective visual search patterns.

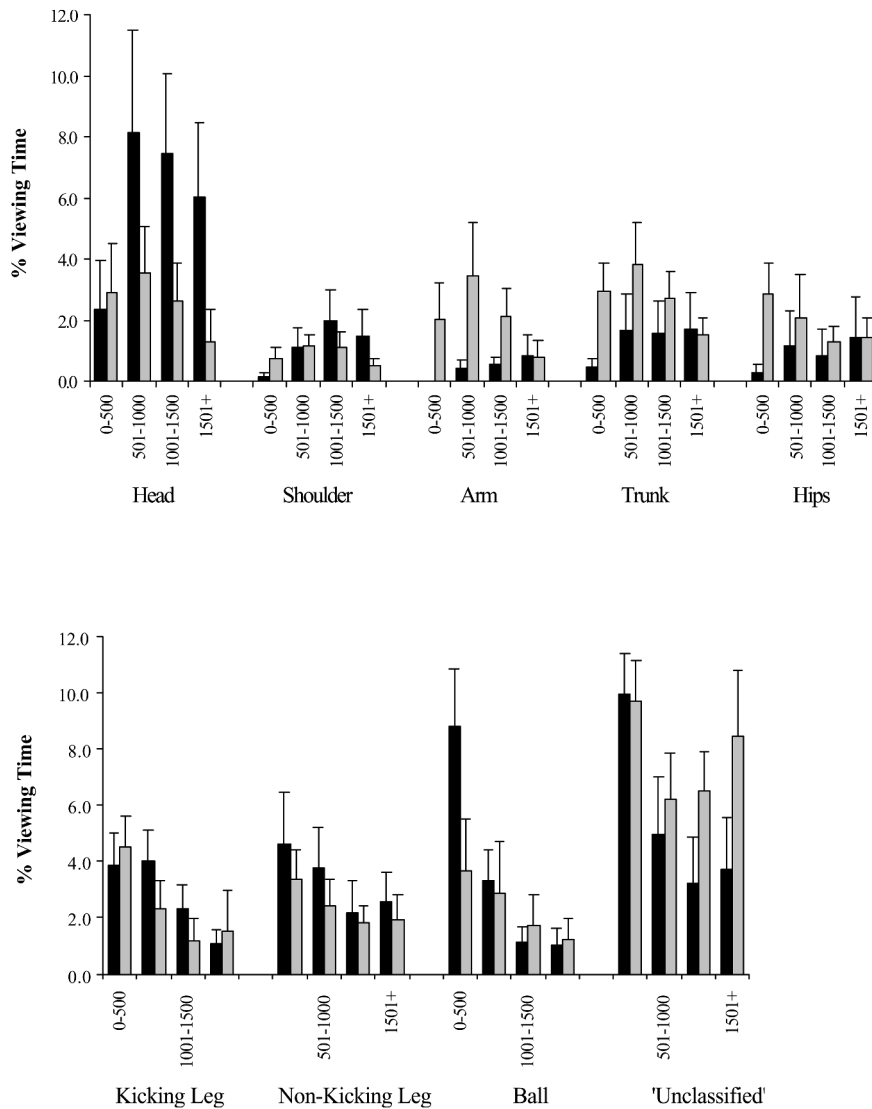


Fig. 3. The percentage of time spent viewing each fixation location for the expert (■) and novice (■) goalkeepers across the four phases of the penalty kick (mean \pm s.e.). The moment of ball contact by the penalty taker occurred within the 0–500 ms period; the 1500+ ms period included a portion of the run up.

A secondary aim was to determine whether there were any differences in visual search behaviour on successful versus unsuccessful penalties.

As predicted, the expert goalkeepers generally demonstrated better performance on the anticipation test than their novice counterparts. Although the total number of penalties saved only approached significance ($P = 0.06$), probably a reflection of the small sample size and high standard deviations, on average the expert goalkeepers saved almost 10% more penalties (an extra 3 of the 30 penalties faced). The experts were also more accurate than the novices in predicting penalty kick side (83.8 vs 71.4%) and height (38.5 vs 26.3%). The results support previous research involving ‘open play’

(Williams *et al.*, 1994; Williams and Davids, 1998) and penalty kicks (Tyldesley *et al.*, 1982; Williams and Burwitz, 1993, Franks and Hanvey, 1997) in soccer. As a result of their more refined task-specific knowledge structures and improved strategic processing of information, experts are able to interpret events encountered in circumstances similar to those previously experienced (see Williams, 2000).

Both groups of players were more accurate in predicting the correct side rather than height of the penalty kick (77.6 and 37.9%, respectively). This finding supports previous studies (Salmela and Fiorito, 1979; McMorris *et al.*, 1993; Williams and Burwitz, 1993) and suggests that postural cues relating to the height of the penalty

kick are more subtle and harder to pick up than those responsible for conveying the correct side. Although this latter observation may be due to the loss of dimensionality when using film rather than 'live models', recent research suggests that similar difficulties in predicting depth are evident in the field setting (see Starkes *et al.*, 1995).

The expert goalkeepers initiated their joystick movements later or nearer to foot-ball contact than the novices and made corrections on fewer trials. The experts initiated joystick corrections around 300 ms before foot-ball contact, whereas the novices commenced their movements almost 500 ms before the penalty taker made contact with the ball. The experts made corrective movements of the joystick on 26% of trials compared with 38% for the novices. This finding may highlight a deliberate strategy on behalf of the expert to allow more time to pick up information before initiating a response. Such strategies have been reported when attempting to intercept a ball in flight (see Oudejans *et al.*, 1997; Rodrigues *et al.*, 1999). Oudejans *et al.* (1997) showed that when attempting to catch fly balls expert catchers initiated their movements towards the ball later and made fewer corrective actions before interception. Similarly, Rodrigues *et al.* (1999) showed that skilled table tennis players are able to 'buy extra time' relative to less skilled performers by taking the ball later during its approach, compensating for this delay by adopting shorter movement times. It would appear that skill in fast ball sports is at least partly dependent on the ability to develop effective strategies to overcome various structural constraints on performance. Another possibility is that the information available early in the run-up is redundant for experts and that the crucial postural cues only emerge around 300 ms or so before contact.

There were clear differences in visual search behaviours across groups. The expert goalkeepers used a search strategy involving fewer fixations of longer duration to fewer areas of the display than their novice counterparts. The experts' less exhaustive search pattern has also been shown to be effective in time-constrained 'open play' in soccer (Helsen and Pauwels, 1993; Williams and Davids, 1998; Helsen and Starkes, 1999). Experts are able to reduce the amount of information to be processed or require fewer fixations to create a coherent perceptual representation of the display (Abernethy, 1990). Alternatively, the reduced search rate may reflect greater use of peripheral vision (Williams and Davids, 1998) or more refined attunement to the relative motion information presented within the display (Savelsbergh and Van der Kamp, 2000; Ward *et al.*, 2002).

The novices spent longer fixating on the trunk, arm and hip regions as the penalty kick evolved, whereas the

experts preferred to fixate their gaze on the kicking leg, non-kicking leg and ball areas. The expert goalkeepers also spent longer fixating on the head region, particularly early on, although this may reflect a tendency to try and recognize facial characteristics early in the action sequence. The kicking leg and ball have previously been identified as potentially informative areas of the display (Tyldesley *et al.*, 1982; Williams and Burwitz, 1993), whereas more recent research has highlighted the importance of the non-kicking leg (see Franks and Hanvey, 1997). Franks and Hanvey (1997) argued that the non-kicking foot is positioned so that it points towards the ball's likely destination, while Williams and Burwitz (1993) proposed that the angle of the foot relative to the ball during the downswing phase provides a strong indication of intended ball placement. The advantage of these two sources of information over other potential cues is that they occur early enough for the goalkeeper to initiate a response, but not too early so as to be 'fooled' by some element of disguise on behalf of the penalty taker. Moreover, both these information cues are located near to the ball and in close proximity to each other, thereby reducing the need to scan the display exhaustively.

Interestingly, both groups of players spent long periods fixating on 'unclassified' areas of the display. These 'unclassified' areas included fixations near to, but not on, the lower leg and ball regions. This suggests that participants chose to anchor the fovea close to these key locations so that they could use the parafovea and visual periphery to pick up relevant information. The effective use of such 'visual pivots' by experts has been demonstrated in a variety of sports (see Ripoll *et al.*, 1995; Williams and Davids, 1998; Williams and Elliott, 1999). It may be, as suggested by Ward and others (e.g. Abernethy *et al.*, 2001; Ward *et al.*, 2002), that each specific information cue is less important than the relative motions between these areas (i.e. kicking leg, non-kicking leg and ball). There is also evidence to suggest that relative motion information is picked up more effectively via peripheral vision, which is more sensitive to movement than the fovea (see Williams *et al.*, 1999).

No significant differences in visual search behaviours were observed across successful and unsuccessful trials, implying that perceptual skill is only partially dependent on the visual search strategy used (cf. Abernethy, 1990). According to this interpretation, experts' superior performance over novices may reflect the more effective extraction of information per foveal fixation or greater use of peripheral vision. This issue needs to be addressed in future research by employing other measures of cue usage, such as verbal reports and event occlusion techniques, in conjunction with eye movement registration methods (see Williams and Davids, 1998).

Another important area for future consideration is whether goalkeepers' anticipatory performance at penalty kicks can be improved through perceptual training. In a recent review, Williams and Grant (1999) suggested that cognitive interventions that develop the knowledge bases underlying skilled perception would appear to have practical utility in facilitating the acquisition of expert performance. Video simulation may prove particularly effective as a method of developing perceptual skill, particularly when coupled with appropriate instructional techniques (see McMorris and Hauxwell, 1997; Williams and Burwitz, 1993). The key issue is whether information derived from this study can be used to train novice soccer goalkeepers. One approach may be to highlight the importance of the kicking leg, non-kicking leg and ball, perhaps using video, and explain how subtle variations in the orientation of the feet relative to the ball can help predict penalty kick direction. Research is currently underway to examine how such a training programme may be designed, implemented and evaluated to facilitate effective transfer.

In summary, the current findings indicate that expert goalkeepers have superior perceptual skills to their novice counterparts. Experts are quicker and more accurate in anticipating the likely destination of a penalty kick and systematic differences in visual search behaviours were apparent across groups. Experts use a more selective search pattern involving fewer fixations of longer duration to less disparate areas of the display. The expert goalkeepers also tended to spend more time fixating on the kicking leg, non-kicking leg and ball regions, particularly as the moment of foot-ball contact approached. No differences in search behaviours were observed across successful and unsuccessful trials, implying that perceptual skill at penalty kicks is due to the efficient extraction of information per fixation. Further research is required to clarify this issue and to determine whether perceptual training programmes can improve anticipation at penalty kicks. Finally, although the paradigm used in this study is more realistic than in previous research, further innovations are required to accurately simulate the performance setting. These innovations could include whole-body response measures and the manipulation of emotional states such as anxiety and motivation.

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