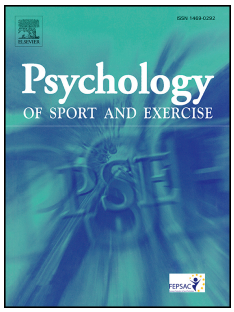

Psycho-perceptual-motor skills are deemed critical to save the penalty corner in international field hockey

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PII: S1469-0292(20)30211-9

DOI: https://doi.org/10.1016/j.psychsport.2020.101753

Reference: PSYSPO 101753

To appear in: *Psychology of Sport & Exercise*

Received Date: 19 March 2020

Revised Date: 30 June 2020

Accepted Date: 30 June 2020

Please cite this article as: Morris-Binelli, K., van Rens, F.E.C.A., Müller, S., Rosalie, S.M., Psycho-perceptual-motor skills are deemed critical to save the penalty corner in international field hockey, *Psychology of Sport & Exercise* (2020), doi: https://doi.org/10.1016/j.psychsport.2020.101753.

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Psycho-Perceptual-Motor Skills are Deemed Critical to Save the Penalty Corner in International Field Hockey

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Declaration of interest: None.

Funding source: This research received no grant funding.

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Second Revision

Psycho-Perceptual-Motor Skills are Deemed Critical to Save the Penalty Corner in International Field Hockey

Abstract

In interceptive sports such as field hockey goalkeeping, the psycho-perceptual-motor skill anticipation is vital for performance due to the extreme time constraints associated with saving a goal. The purpose of this study was to understand the beliefs and attitudes of international field hockey goalkeepers and coaches regarding anticipation of the drag-flick in penalty corners. Seven international goalkeepers and five international coaches were interviewed. Using a constructionist and relativist approach to reflexive thematic data analysis, we identified three overarching themes to anticipate the drag-flick, namely pre-match video analysis, perception and action, and psychological factors. In the first theme, participants reported that pre-match video analysis allowed goalkeepers and coaches to identify the attacking capabilities of opposing teams. This analysis was used to inform defensive structure and save the drag-flick. In the second theme, participants reported that perception and action, which consisted of the pick-up of visual cues and movement execution, was important to anticipate the drag-flick. Goalkeepers reported that they rely heavily on ball flight, which was central in coaches' approaches in training drills such as to use a projection machine that presents only ball flight information. The third theme, psychological factors, encompassed, psychological resilience, arousal regulation, leadership and communication, and sports intelligence, which were thought to be vital to facilitate anticipation of the drag-flick. The findings of this study have important implications for how to assess and train visual anticipation in time-constrained interceptive sports skills.

Keywords: visual anticipation, psycho-perceptual-motor skill, sport expertise, performance psychology

Psycho-Perceptual-Motor Skills are Deemed Critical to Save the Penalty Corner in International Field Hockey

Experts in high-speed interceptive sports are required to perform their skills under extreme time constraints of less than 1 second (Baker, Farrow, Elliott, & Anderson, 2009; Williams & Jackson, 2019). The capability to perform these ballistic skills has been reported to be due to superior psychological and perceptual-motor (*psycho-perceptual-motor*) factors (Cocks, Jackson, Bishop, & Williams, 2016). The perceptual-motor component refers to the capability of the performer, such as a field hockey goalkeeper, to pick-up visual information from the immediate environment to achieve the motor skill goal, such as to save a penalty corner drag-flick on goal (Williams & Jackson, 2019). The psychological (*psycho-*) component refers to factors such as the capability to manage emotions like anxiety, which are inherent in high-pressure sport performance (Weissensteiner, Abernethy, & Farrow, 2009). This is important because emotions can influence the pick-up of visual information, which, in turn, can influence achievement of the motor skill goal (Cocks et al., 2016). Consequently, when investigating expertise in high-speed interceptive sports, it is important to consider psycho-perceptual-motor skills, as these are vital for superior performance in sport (Buekers et al., 2017; Müller et al., 2019).

A key perceptual-motor skill for performance in high-speed interceptive sports is visual anticipation (Williams & Jackson, 2019). Visual anticipation is defined as the capability to pick-up visual information in the immediate environment to predict what will happen and guide action (Runswick, Roca, Williams, McRobert, & North, 2018). For example, in field hockey goalkeeping during the penalty corner at international level, the drag-flicker delivers the ball at approximately 120 km/h meaning that it reaches the goalkeeper within 350 milliseconds (Baker et al., 2009). As a drag-flicker can direct the ball to a minimum of four goal locations (Rosalie et al., 2017), this results in a four-choice visual

reaction time for the goalkeeper, which can be approximately 400 milliseconds (Müller & Abernethy, 2012). Consequently, the goalkeeper needs to utilize advance information (visual cues prior to ball flight) to circumvent this reaction time delay through anticipation of the ball's location in order to respond in a timely manner (Abernethy, 1987; Müller & Abernethy, 2012). Understanding what players and coaches believe as important information for anticipation, can provide insight into the information consciously attended to during skill performance. This presents an opportunity to assess and train pick-up of advance information for superior anticipation.

There is considerable quantitative evidence on how experts differ from lesser-skilled performers in the pick-up of information to anticipate (Williams & Jackson, 2019). Specifically, experts are superior to lesser skilled players in the pick-up of contextual information to anticipate (Williams & Jackson, 2019). Contextual information can be visual, such as opponent server positioning on the tennis court before the serve is delivered that can be used to predict stroke or serve type (Abernethy, Gill, Parks, & Packer, 2001; Loffing & Hagemann, 2014). Alternatively, contextual information can be non-visual, such as prior knowledge of action preferences of an opponent(s) or game score that can be used to predict handball throw direction or ball location in cricket batting (Mann, Schaefers, & Cañal-Bruland, 2014; Runswick, Roca, Williams, McRobert, et al., 2018). In addition, experts are superior to lesser-skilled players in the pick-up of kinematic information, such as from the bowler's ball and bowling hand or tennis server's racquet position, to anticipate ball location (Jackson & Mogan, 2007; Müller, Abernethy, & Farrow, 2006). Based on this evidence, researchers have formulated a model of how experts use visual and non-visual information to anticipate.

Initially, Müller and Abernethy (2012) proposed a two-stage model for expert anticipation in high-speed striking sports. This model was later updated by Morris-Binelli and

Müller (2017) to take into consideration the growing body of evidence on the topic of anticipation in sport. Stage one of this model outlines that visual and non-visual contextual and kinematic (*advance*) information occurring before object flight can be used to guide positioning of the body in the sport skill. For example, in a tennis game, the returner can use the server's court positioning (visual contextual) and the server's action preferences (non-visual contextual – known prior to game), as well as ball toss (kinematics) to predict serve direction. In stage two, the model outlined the use of object flight information to guide interception. For example, in a tennis game, the returner can use early ball flight and bounce information to strike the ball. Since formulation of the initial model, in-situ quantitative evidence has confirmed that kinematic information is used for body positioning (e.g., Triolet, Benguigui, Le Runigo, & Williams, 2013), and ball flight for interception (e.g., Land & McLeod, 2000; Müller, Brenton, Dempsey, Harbaugh, & Reid, 2015).

In order to understand the conscious attention to information in sport, a number of studies have used verbal report with anticipation tasks (e.g., Roca, Ford, McRobert, & Williams, 2011, 2013; Runswick, Roca, Williams, Bezodis, et al., 2018). For example, in a soccer anticipation task, Roca et al. (2013) reported that skilled players made more statements about position between players when the ball was far away (i.e., in the other half of the pitch). In contrast, when the ball was closer to the performer (i.e., near the penalty box), skilled players made more statements referring to opponent postural cues for anticipation. These studies have been valuable in identifying how conscious report of information pick-up relates to anticipation. However, studies utilizing verbal reports provide limited insight into the detailed beliefs and attitudes of performers (Weissensteiner et al., 2009). There is limited information regarding what athletes and coaches believe to be important for anticipation, and whether these beliefs correspond with quantitative studies of anticipation. Understanding these beliefs is valuable, because they may influence what

athletes attend to when practicing their skills and during performance in competition.

While there is a substantial body of quantitative literature on anticipation (see Williams & Jackson, 2019), only two studies have used a qualitative approach to understand athletes beliefs about the pick-up of visual and non-visual information for anticipation (Vernon, Farrow, & Reid, 2018; Weissensteiner et al., 2009). Vernon et al. (2018) reported that professional tennis players were aware of using non-visual contextual information, such as server preferences relative to game score, to anticipate serve direction. The authors also reported that participants placed importance on kinematic information including the ball toss, servers grip, torso rotation, and type of service action, to anticipate serve direction. Weissensteiner et al. (2009) reported that expert cricket batsmen and coaches placed importance on the use of kinematic information for anticipation. The authors also reported the importance of psychological factors such as self-confidence, resilience, and work ethic for cricket batting. These studies have provided useful initial information relating to expert anticipation. However, qualitative studies on visual and non-visual information use and psychological factors for anticipation in complex multi-player sport contexts are scarce. These are important factors to investigate because it provides an understanding of how instructional cues and practice tasks are structured, which may influence the anticipatory skill of athletes (Müller et al., 2019).

Recent research has also focused on how psychological factors impact anticipation (Morris-Binelli & Müller, 2017; Williams & Jackson, 2019). Psychological factors encompass a range of constructs such as; arousal regulation in response to anxiety (Gould, Dieffenbach, & Moffett, 2002), resilience (i.e., mental processes and behaviour that safeguard performance under stressors; Fletcher & Sarkar, 2012), leadership and communication (i.e., capability to make decisions and provide clear instructions to others under pressure; Sonesh, Lacerenza, Marlow, & Salas, 2018), and sports intelligence (i.e.,

understanding of the game being played which facilitates effective gameplay; Gould et al., 2002). For example, Cocks et al. (2016) found that anxiety impaired skilled tennis players' capability to pick-up contextual information (i.e., positioning of opposition player on the court) to anticipate stroke direction. Alder, Ford, Causer, and Williams (2016), however, demonstrated that anticipation could be improved under higher levels of anxiety. Collectively, these findings demonstrate the need to understand how psychological factors influence anticipation.

The purpose of this study was to gain a rich and detailed insight into the beliefs and attitudes of international field hockey goalkeepers and coaches to anticipate the penalty corner drag-flick. This was important because coaches structure practice and preparation as well as game play, so both their views are integral to saving the penalty corner. The penalty corner is a highly complex strategic part of a field hockey game, which provides the attacking team a prominent opportunity to score (Laird & Sutherland, 2003). The penalty corner presents a multitude of information to the defending goalkeeper, including multiple opposition player setups, movement of opponent players towards the goal, and multiple locations for the drag-flicker to score. Further, the goalkeeper's own defensive players can either limit or increase shot locations in which the drag-flicker can score. Therefore, saving the drag-flick provides a complex example to understand what athletes and coaches believe to be important information sources to attend to in order to anticipate. In addition, multiple movements of offensive and defensive players create a highly pressurized local environment, which can provide insight into psychological factors relating to anticipation of the drag-flick.

Method

Philosophical Assumptions

To capture the participants' beliefs and attitudes to anticipate the drag-flick, we used a qualitative approach, which was underpinned by interpretivism and framed ontologically by

relativism and epistemologically by constructionism. Relativism accepts that there are multiple and subjective realities, whereby contradictory, but equally valid accounts of the world can exist, while constructionism considers knowledge as subjective and socially constructed (Sparkes & Smith, 2014).

Participants

Seven goalkeepers (M_{age} = 29, *SD* = 2.40) and five coaches (M_{age} = 43, *SD* = 9.70) from the National field hockey high-performance unit were interviewed, which accounted for 100% of the population of international level field hockey goalkeepers and 71% of the population of international level field hockey coaches in Australia. Four goalkeepers were members of the National male field hockey team, and three goalkeepers were members of the National female field hockey team. On average, the goalkeepers had participated in 99 (*SD* = 72.80) international matches and had been playing competitively as goalkeepers for 18 years (*SD* = 4.39). The coaches included the head coach and two assistant coaches from the National male field hockey team, an assistant coach for the National female field hockey team, and the National specialist goalkeeping coach for both male and female teams. On average, the coaches had nine years of experience coaching at international level (*SD* = 7.30). During their playing careers, all coaches had competed in field or indoor hockey at international level, whilst the specialist goalkeeping coach had played field hockey at international level as a goalkeeper.

Interview Procedure

Ethical approval from the relevant university ethics committee was obtained prior to the study commencing. Participants were recruited via the National Australian field hockey high-performance unit. At the start of each interview, the interviewer introduced himself, reminded the participant of the purposes of the interview, and provided an opportunity for the participants to ask any questions they may have. Each participant was interviewed

individually and provided written consent to participate and be audio recorded, prior to the interview commencing. Interviews took place at a location chosen by the participant to accommodate the participants' busy schedules (e.g., private offices at Hockey Australia). Interviews ranged from 28 to 48 min (M = 36.8 min, SD = 6.4 min) in duration.

Interview Guide

A semi-structured interview guide in accordance with recommendations by Smith and Sparkes (2016) was developed by the authors to cater for both flexibility and organization in the interview process (Gillham, 2005). Impromptu elaboration (e.g., "any others?") and clarification (e.g., "can you explain what you mean by that?") probes were used throughout the interview. This method of interviewing allows for a deeper understanding of the participants' beliefs and attitudes in relation to the question (Smith & Sparkes, 2016).

The interviewer (first author) further adapted and refined the interview guide following pilot interviews. The final interview guide (see supplementary material) consisted of open-ended questions concerning the participants' training practices to prepare for penalty corners, beliefs of sources of information used to anticipate during the penalty corner, and opinions of psychological and movement execution factors important for success in a penalty corner. Where required, question wording was adjusted to suit the different roles of goalkeepers and coaches. Upon completion of each interview, participants were provided with an opportunity to ask questions and provide additional comments. While all questions were addressed, the order of the questions and exact phrasing was individualized according to each participant's responses.

Data Analysis and Quality

The interviews were transcribed verbatim by the first author and imported into NVIVO 11 qualitative data management software. To ensure the participants' confidentiality, each participant was assigned an identifying label. Goalkeepers were given goalkeeper

specific labels (e.g., GK1) and coaches were given coach specific labels (e.g., C1), so that the beliefs and attitudes of coaches and goalkeepers could be easily recognized. As we wanted to identify similarities and differences in the beliefs of participants, the analysis of goalkeepers and coaches was not separated. Additionally, all potentially identifiable information was removed from the transcripts (e.g., opposition drag-flicker team names). A constructionist approach to reflexive thematic data analysis was chosen in which the socially produced and reproduced experiences and realities of the participants were deemed central (Braun & Clarke, 2019; Burr, 1995). We used a data-driven, inductive orientation to identify all themes in the data, which was not coupled to pre-existing theories, as well as a deductive orientation to link identified themes – where possible – to existing theories (Braun & Clarke, 2006, 2019; Braun, Clarke, Hayfield, & Terry, 2018; Braun, Clarke, & Weate, 2016). Themes were identified at a semantic level, whereby the explicitly stated beliefs and attitudes of the participants were coded and analyzed (Braun et al., 2016).

The six phases to reflexive thematic analysis were followed (Braun & Clarke, 2006; Braun et al., 2018). These phases were implemented in a recursive, rather than linear, manner as the process of data coding and analysis is iterative and develops organically as researchers actively engage with, and reflect on, the data (Braun & Clarke, 2019). In the first phase, the lead author immersed himself in the data by transcribing the interviews and reading the transcripts multiple times while noting initial observations and ideas and reflecting on how he responded to the data. The second phase involved complete coding of the entire data set, whereby the transcripts were separated into meaningful units of text, which were coded and collated to develop a diverse range of codes from which to build themes. The third phase consisted of organizing the codes into potentially related, but distinct ‘candidate’ themes. The authors met regularly throughout this phase to discuss and reflect on the candidate themes, and identify themes which told the best story of the data. In the fourth phase, the ‘candidate’

themes were cross-checked with the coded extracts and refined to produce a thematic 'map' of the analysis. These themes were further cross-checked with the entire data set to ensure they accurately reflected the data and to code for additional data within the themes that may have been missed in earlier phases. The next phase entailed continued discussion and reflection between the authors to refine each theme, identify sub-themes, and finalize clear definitions and labels for each theme. The final phase consisted of producing the written report and selecting compelling extracts that captured the meaning of the themes and related to the research questions.

Consistent with our relativist approach, validity was not determined by a list of pre-existing quality criteria. Rather, we used various study-specific, contextually situated quality verification strategies, which were embedded in the qualitative research process (see Burke, 2016). These criteria included: topic worthiness and generalizability; contribution of the study to increase the understanding of successful performance in time-constrained interceptive sports from the perspective of athletes and coaches; external coherence with existing theories and studies; and transparency in the form of an audit trail outlining the data collection and analysis process (Smith, 2018; Tracy, 2010). To attain rich rigor, we interviewed a highly distinctive sample of participants, who made up 86% of the population of elite field hockey goalkeepers and coaches in Australia. Additionally, the interviewer spent considerable time with the participants before and after the interviews, and transcribed each interview verbatim (Burke, 2016; Tracy, 2010). To ensure reflection and thoughtfulness, and increase the credibility and trustworthiness of the data, multiple discussions took place between the research team during analysis to verify that alternative interpretations of the data were considered (Smith & McGannon, 2018). To increase the confirmability of the study, the second and third authors served as critical friends during phase 2 to 6 of data analysis (Burke, 2016). As a group, the authors discussed differences in themes and interpretation to ensure

reflective, thoughtful and collaborative engagement in order to generate rich accounts of the data (Braun & Clarke, 2019).

Results

In examining participants' beliefs and attitudes to anticipate penalty corners, we identified three first-order themes: pre-match video analysis, perception and action, and psychological factors. An overview of first, second, and third-order themes can be found in Figure 1.

[Insert Figure 1 here]

Pre-Match Video Analysis

In high-performance teams, pre-match video analysis consists of an athlete or coach viewing pre-collected video footage of the opposition with sophisticated software, to inform preparation for upcoming matches (C. Wright, Atkins, Jones, & Todd, 2013). All participants reported that pre-match video analysis of the opposition was a key determinant of successful performance in a penalty corner. This video analysis consisted of identifying who takes shots on goal during a penalty corner and the different attacking formations the opposition runs. Further, participants mentioned they analyze the action capabilities and movement techniques of opposition drag-flickers, such as their footwork, to understand where they may direct the ball, as well as the percentage of goal locations they flicked towards:

> I watch for whether the [drag-]flicker has anything different about their technique to give away where they're delivering the ball […]. Do they have a preferred side? Do they have a flick that they like to flick under pressure? (GK1).

Participants deemed pre-match video analysis important because they felt it gives goalkeepers the ability to familiarize themselves with the movement patterns and techniques of the opposition's drag-flickers: "We will do our own study of them [drag-flicker] and learn their technique. We can't replicate that because we don't have the flickers here." (GK2).

Participants further reported that they use the information from the video analyses to prepare for and rehearse the likely scenarios which they may encounter in a penalty corner, which they thought leads to better saving performance. The goalkeepers described using this information during a penalty corner to guide their defensive formation to reduce the attacking team's scoring ability:

> When the penalty corner is awarded, I'll look at what personnel they have on. […] I would have already had a pre-plan of which corners I'll run if what personnel's on. […] I'll get to our guys and I'll say "look, the priority is [specific opposing drag-flicker], he's our number one. We're going to run a 1-3. He's on battery one so that's our priority." (GK4).

Four participants stated that pre-match video analysis is most beneficial when the team's goalkeepers, drag-flickers and defenders carry out the video analysis of the opposition together. These participants thought that this group analysis provides the goalkeepers with unique insights into the action preferences of opposition drag-flickers, as well as an increased understanding between the goalkeeper and defenders of how best to counteract the oppositions capability to score: "I really like doing my PCD [penalty corner defense] analysis with the drag-flicker, because they pick up on things that I wouldn't pick up on." (GK3).

Although all participants reported that pre-match video analysis of the opposition is important to improve goal-saving performance, five participants stressed that this information should be used with a degree of caution because opposition teams may change their penalty corner tactics between games or tournaments. As a result, the analyzed footage may no longer be relevant to inform the goalkeeper's tactical decisions (e.g., defensive formation) and interceptive actions. Additionally, four participants were concerned that relying too heavily on information from the video analysis can distract the goalkeepers from utilizing the visual cues they are presented during the *live* penalty corner: "That's where all that homework can

stitch you up. All that prior knowledge can undo the work, because you have to still react to what the cues are in front of you." (C2). Further, one goalkeeper and coach conceded that the high filming angle (e.g., from a tower overlooking the hockey goal) often used to capture the video analysis footage, makes it difficult to pick-up fine-grained differences in drag-flicker movement techniques.

Taken together, these findings are consistent with the performance analysis literature, which indicates that athletes utilize pre-match video analysis of the opposition to guide tactical decision making and movement responses in match situations (e.g., Francis & Jones, 2014). Ten coaches and goalkeepers, however, stressed that information derived from the *live* penalty corner supersedes information derived from pre-match video analysis to guide anticipation.

Perception and Action

In interceptive skills, perception and action refers to the pick-up of information (e.g., contextual, opponent kinematic, and early ball flight) in the performance environment to achieve the motor skill goal (Morris-Binelli & Müller, 2017). Within perception and action, we identified two second-order themes: the pick-up of visual cues and movement execution.

Pick-up of visual cues. Participants described that the pick-up of visual cues is key to anticipate a drag-flick shot on goal. Within this, we identified three third-order themes, namely contextual, kinematic and ball flight information. Cues from these visual information relate to the two-stage model of expert visual anticipation in striking sports (Morris-Binelli & Müller, 2017).

Contextual information. Participants agreed that critical information regarding the opposition team's game strategy in the penalty corner could be discerned by pick-up of contextual cues. During the set-up for the penalty corner, key sources of contextual cues are identification of which attacking players are gathering "on top of the penalty circle" (C5),

"where [attacking] players are set up" (GK7) on the penalty circle, the attacking players' "body language" (GK2), the "time of the game" (GK1), "the score" (GK1) of the match, and how "fatigued" (C1) the drag-flickers appeared to be. Goalkeepers may use these contextual cues in combination with their knowledge from video analysis to determine which drag-flicker is most likely to take the shot at goal, and where the shot is likely to be played:

> So, you roughly know where they're [drag-flicker] going to score […]. You might say that their main flicker on battery one tends to try to flick glove side [left of goal] from there, but on battery two he tries to pull it across [the goal]. (GK3).

Seven participants, however, were hesitant to use contextual cues occurring during the set-up of the penalty corner, to initiate the saving action. These participants thought that any action based on this early contextual information involves "guesswork" (C4) by the goalkeeper about where the ball will go. This guesswork was considered a key factor of unsuccessful save performance, as it can distract from the pick-up of more reliable sources of information, which are thought to occur later in the penalty corner (e.g., ball flight): "I think the most important thing for me is not to predict. Watch the ball." (C3). These views are supported by recent research, which indicates that anticipation performance of skilled performers decreases when they use contextual information (e.g., previous action preferences of an opponent), which is incongruent with kinematic and ball flight information (e.g., Loffing, Stern, & Hagemann, 2015; Runswick, Roca, Williams, McRobert, & North, 2019).

Once the penalty corner has commenced, 10 participants reported that it is critical to identify which drag-flicker is taking the shot on goal, and the location on the penalty circle the shot is about to be delivered. Three goalkeepers mentioned using these contextual cues to guide body positioning in the goal.

> The first cue is which battery the ball goes to, because that affects where we stand.
>
> So, your initial set up will be dependent on where the ball goes. Then […] you're just

> looking at […] the movement at the top – who's going to be taking the actual shot. (GK6).

Further, one goalkeeper and one coach reported that the position of the running defender (i.e., defender who runs out towards the drag-flicker) relative to the penalty spot, should determine the goalkeeper's position in the goal. This suggests that the pick-up of contextual information is important to guide positioning of the goalkeeper's body in preparation for interception, which relates to part of stage one in the model of expert visual anticipation (Morris-Binelli & Müller, 2017).

Additionally, four goalkeepers reported that the way the ball is trapped prior to the drag-flicker collecting the ball onto their stick, is a useful contextual cue to determine whether a drag-flick or a hit (latter with higher stick back lift and must cross the goal line within the height of the backboard in the goal) will be executed:

> […] you know it's going to be a flick because they [trapper] trap it outside [the penalty circle] and drag it in. […] If it's going to be a hit, they trap it and bunt [tap] it inside the circle. (GK5).

Awareness of this contextual cue provided goalkeepers with more time to prepare to execute the appropriate movement response.

Participants reported that penalty corner drills that include all attacking and defensive players are "the best" because "they've got to factor in certain variations the opposition might use, […] there's some decision making there." (C4). Yet, despite the benefit of and desire to conduct these drills regularly, this was not always possible due to the high-risk of defensive players getting injured by being hit with the hockey ball (see Dick et al., 2007): "we don't do them a lot [full penalty corner defense drills] because of the fact there is more chance of injury for the defenders." (GK5).

Collectively, these findings illustrate that visual contextual information is considered

an information source to anticipate and guide part of the goalkeeper's action during a penalty corner. Accordingly, contextual cues that occur during the execution of the penalty corner are deemed more important than earlier occurring non-visual contextual cues. However, participants also reported that the drag-flicker's movement pattern (*kinematics*) provides important cues for anticipating the drag-flick.

Kinematics. Consistent with previous research (e.g., Baker et al., 2009; Causer, Smeeton, & Williams, 2017; Vernon et al., 2018), we identified that kinematics of the drag-flicker is regarded to contain cues in order to anticipate where the ball is targeted. Examples of drag-flicker kinematic cues that were deemed important by the participants were "how far across they're stepping" (GK7), "the angle of their stick" (GK5), "their distance from the ball" (GK6), "the hand positioning" (GK5), and "the direction they drag it [their stick]" (GK4). Yet, nine participants explained that "everybody has a different technique" (C5), and that kinematic cues are flicker dependent. Therefore, they believed it important to understand the nuances of each individual drag-flicker's movement.

Coaches and goalkeepers are thus aware of the benefits of kinematic cues for anticipation, which is consistent with part of stage one in the model of expert visual anticipation (Morris-Binelli & Müller, 2017). Nine participants, however, reported being hesitant to use kinematic cues to initiate their movement to save. They felt that acting on pre-ball flight information could be detrimental to their save performance because the drag-flicker could attempt to deceive the goalkeeper during their flicking action. For example, some drag-flickers were reported to have a "whipping action" (GK5), implement a "body fake" (GK6), or have the capability to "open up their wrist and put it [the ball] in the opposite direction" (C1) mid-way through their flicking action. Consequently, goalkeepers and coaches emphasized that it is important not to use kinematic cues to guide their interceptive action.

> If you know a flicker is very good at deception, […] you can't move until he flicks it. […] if you move too early […] and they throw it down your left foot and you've moved right, well you look like a goose and you should have saved it. (GK4).

Accordingly, coaches explicitly instructed goalkeepers to consciously wait to observe ball flight before initiating a save, and thus not to act on kinematic cues: "You have to wait until that balls left the stick, and then you choose what you're going to do." (C3). Evidence indicates, however, that experts in interceptive sports can subconsciously pick-up kinematic cues to anticipate, despite being consciously unaware of using such information (Abernethy & Russell, 1987). Therefore, it is possible that the participants are not aware of the extent to which they utilize kinematic cues to initiate their interceptive action, which is vital in order deal with the high-time constraints of a penalty corner drag-flick (Baker et al., 2009; Williams & Jackson, 2019).

Despite the hesitance to use kinematic cues to initiate the saving action, coaches and goalkeepers stated that greater exposure to drag-flickers with different movement techniques is a key way to improve drag-flick saving performance. They believed this would decrease drag-flickers' capabilities to deceive goalkeepers, and would increase the goalkeeper's confidence to use kinematic cues to anticipate drag-flicker shots on goal: "We want to come up against quality [drag-]flickers, with different techniques in the training environment, so that when we see them in a match situation, it's not daunting for them [goalkeepers]. […] they've already trained […] it." (C4). Yet, the participants mentioned that this is difficult to achieve due to the small number of drag-flickers in each squad.

Ball flight. Ball flight was viewed as the most reliable source of information to anticipate a drag-flick shot on goal. Consequently, participants emphasized the importance of waiting for ball flight before responding to save: "You don't start to move until you see that ball coming at you." (GK1). Apart from reducing the effect of deception, focusing on ball

flight was thought to reduce distractions by defensive and opposition players who are moving in the penalty circle. These distractions could lead to incorrect save decisions and missed saves.

> You've got [defensive] runners coming from the left; you've got guys sliding in, […] attackers diving in on the right. There are a whole heap of things happening which are going to distract you from your role. […] watch the ball and trust your technique. (C3).

The high value assigned to ball flight is consistent with views of skilled performers in cricket and tennis, who also rate ball flight as one of the most useful sources of information to anticipate (e.g., Runswick, Roca, Williams, McRobert, et al., 2018; Vernon et al., 2018). Accordingly, the participants' view that ball flight should guide the saving action is aligned with stage two of the model of expert visual anticipation, which states ball flight is used to fine-tune the interceptive movement (Morris-Binelli & Müller, 2017).

Movement execution. Participants described that effective movement execution in the saving action is crucial to anticipate drag-flicker shots on goal. Within this theme, we identified three second-order themes, which are important for effective movement execution, namely: positioning and stance, timing and movement pattern, and automaticity.

Positioning and stance. Participants reported that the positioning of the goalkeeper during the set-up of a penalty corner played an important role in anticipating penalty corner shots on goal. The depth of this starting position relative to the goal line was individualized; however, all goalkeepers were coached to position themselves closer to the right-hand goal post during the set-up of a penalty corner (i.e., *offset*). Consequently, the defensive runners (positioned to the left of the goalkeeper and who run out at the drag-flicker) and postman (protecting the left goal post), are responsible for blocking the drag-flicker from shooting at the left side of the goal: "We want to trust our postie [postman] to make those saves." (GK5).

Participants stated this strategy increased the likelihood of the goalkeepers making saves, as they are responsible for a smaller surface area of the goal:

> They are [defensive runners] forcing that ball onto our goalkeeper. […] what we're trying to do is make the goal as small as possible. So, we're offsetting our goalkeeper to the right side of the goal and forcing the drag-flicker to flick the ball to the right side of the goal. (C3).

Further, most coaches and goalkeepers agreed that a balanced and still stance was required, to allow for optimal timing to "explode" (GK1) towards the ball.

Timing and movement pattern. Based on the importance placed on ball flight information, participants reported that an efficient movement pattern consists of a single interceptive movement directly towards the ball, rather than multiple movements to reach the same position:

> If one of those feet are in the air, or if they're stepping, or jumping, […] or trying to use some kind of kinetic energy before a shot, […] they can't move in the opposite direction until that foot's back on the ground. (C1).

Therefore, a large focus of all penalty corner training drills was to ensure goalkeepers did not initiate their movement until the ball's flight.

Further, participants explained that a successful save does not only aim to save a shot on goal, but also directs the ball towards the sidelines and away from the opposition, so that the attacking team does not get an opportunity to score a rebound:

> We want to give the goalkeeper the best chance to (a) make the save, and (b) only have to make one save. […] if the ball's on the right foot, bring across the left hand. That will rotate your body and force the ball out wide. (C3).

Thus, a substantial proportion of penalty corner training drills used a ball projection machine to engrain this movement pattern through part-practice of saves (e.g., left leg), with high

repetition.

Automaticity. Seven participants reported that saving performance deteriorates when goalkeepers overthink their movement patterns. Thus, participants viewed automaticity of the interceptive movement as a key determinant to anticipate a penalty corner:

> As a junior you're thinking about that stance and all those positions, and where your hands should be. "Coach said be still, coach said I need to jump." Those sorts of things and all that talk in your head is slowing you down from making a [interceptive] decision. (GK1).

Consequently, participants deemed movement automaticity a key component of goalkeeper training sessions. The ball projection machine was used as the main training tool to make saves with different interceptive movement responses automatic (e.g., left glove save vs right foot save). Relating to these beliefs and practices, research has reported that when movement automaticity is achieved, less attentional resources are required to monitor explicit movement execution steps (Gray, 2004). Therefore, more attentional resources can be directed to the detection of task-relevant information (e.g., positioning of attacking players).

Psychological Factors

Consistent with a plethora of research (e.g., Burns, Weissensteiner, & Cohen, 2019; Fletcher & Sarkar, 2012; Gould et al., 2002; Gould & Maynard, 2009), we identified that psychological factors were deemed vital for anticipation in a penalty corner. Within this, we identified four second-order themes, namely, psychological resilience, arousal regulation, leadership and communication, and sports intelligence.

Psychological resilience. The participants agreed that psychological resilience was key to anticipate the drag-flick:

> Mentally you need to be very resilient. In no other position on the field does a mistake get highlighted in big neon lights for everyone to see. So, you need to be very content

> as you get older in doing everything that you can and making sure that scoring a goal is as hard as possible, but you also need to understand that sometimes goals go in and that just happens. (GK7).

Consistent with the model of psychological resilience and optimal sport performance (see Fletcher & Sarkar, 2012), participants mentioned that the best goalkeepers "need to be confident" (GK7) in their ability, motivated to continuously improve and "not just go through the motions" (GK3) at training, and have a positive personality to be "persistent […] through terrible periods of poor form" (GK2), and accept that "you're going to let goals in" (GK4). Participants also specified that these attributes reduced the likelihood of goalkeepers' letting mistakes (e.g., conceding a goal) negatively affect the next opportunity to save, and allowed them to thrive off performance pressure, to achieve optimal performance.

Further, participants stated that "focus is very important" (GK3) to increase the goalkeeper's capability to identify relevant cues. Focus was deemed important to decrease distraction by irrelevant information (e.g., "crowd noise" C4), and allow goalkeepers to attend to the game "intensely […] whilst actually not being involved for a lot of it." (GK7). This finding too is consistent with Fletcher and Sarkar (2012) model of psychological resilience and optimal sport performance.

Arousal regulation. Consistent with previous research (see Gould & Maynard, 2009), participants deemed the capability to regulate arousal levels during moments of high pressure in a game or competition as crucial because "you have to have the ability to think clearly under pressure." (C3). Similar to other elite athletes (e.g., Burns et al., 2019; Weissensteiner et al., 2009), the goalkeepers in our study reported using self-talk (e.g., "stay ready, stay relaxed, and not moving too early." GK1), physical habits (e.g., "grip my stick tighter." GK5), and breathing exercises to achieve optimal arousal levels:

> I found during competitions you can get nervous, or your heart rate can spike. So once

a penalty corner's called, […] I do a short breathing exercise. It's just to calm down and lower my heart rate, and just focus a bit more. (GK2).

These findings reiterate previous studies, which report that effective arousal regulation is key to facilitate performance under pressure, such as during a penalty corner in an Olympic final (Gould & Maynard, 2009).

Leadership and communication. In accordance with research investigating discriminating traits of expert teams (see Sonesh et al., 2018), all participants stated that strong leadership by the goalkeeper was critical to be successful in a penalty corner. To facilitate a goalkeeper's strong leadership, effective communication with their defensive teammates was deemed key. This includes conveying information about the opposition's positioning and instructions of the defensive formation.

You're not going to make it as a good [goal]keeper if you can't communicate well. […] We call the PC [penalty corner] variations, we call our defense [positioning], we set everything up. So, if you can't communicate, you're going to struggle. (GK5).

Furthermore, participants reported that strong leadership involves the capability to make decisions at critical times during the game, calm teammates' emotions, and provide clear instructions of what is required by each defensive player during the penalty corner. Participants felt that this capability increased the defensive players' confidence so they can execute their roles effectively.

People don't want short corners awarded against them. They go crazy, they're shouting at umpires, it's chaos. […] the good goalkeeper will calm everyone down, have a plan, look at what's going on up front [on the penalty circle], and say, "okay, this is what we're doing guys, run hard, let's go." (C3).

Sports intelligence. Seven participants mentioned that goalkeepers with high levels of sports intelligence were better able to provide their teammates with the most relevant

information regarding what the opposition was about to do. Consequently, such goalkeepers were able to direct teammates to positions which would reduce the oppositions capability to score:

> You have to be able to see patterns. You have to be able to see things unfold from the defensive point of view early, so you can organize and position your defenders in the best possible way and give them the best information, so that they can do their role in the best possible way. (GK3).

This finding is consistent with Gould et al. (2002) who reported that 10 Olympic champions were characterized by high levels of sports intelligence.

Discussion

In this study, we investigated international field hockey goalkeepers and coaches' beliefs and attitudes towards anticipation of the drag-flick within penalty corners using semi-structured interviews. The findings indicated that pre-match video analysis, perception and action, as well as psychological factors were deemed key to expert performance. Perception and action during the penalty corner consisted of the pick-up of visual cues (i.e., contextual, kinematic, and ball flight information) and movement execution (i.e., positioning and stance, timing and movement pattern, and automaticity). Psychological factors that were deemed important included psychological resilience, arousal regulation, leadership and communication, and sports intelligence.

Our findings align with the updated two-stage model of expert anticipation (Morris-Binelli & Müller, 2017). Goalkeepers and coaches indicated that contextual (visual and non-visual) and kinematic advance information are important to save the drag-flick. This is consistent with stage one of this model, which states that advance information can be used to guide positioning of the body. However, participants ascribed greater importance towards the use of ball flight to guide the interceptive movement to save the drag-flick. This aligns with

stage two of the model, which describes that ball flight information is used to guide interception of the object. A quantitative study using the temporal occlusion paradigm, where progressive footage of the penalty corner is presented, is recommended to determine whether goalkeepers can pick-up visual contextual, kinematic or ball flight information to anticipate. Such a study, considered in combination with this qualitative study, presents a promising mixed methods approach to determine whether beliefs of information pick-up align with quantitative data of anticipation. In addition, a separate study could investigate the use of non-visual contextual information gathered through pre-match video analysis, and compare it to visual contextual and kinematic information pick-up from the temporal occlusion paradigm. This would probe whether knowledge acquired prior to perceiving the penalty corner benefits or impedes anticipation. Collectively, these future research studies can further inform the predictions of the two-stage model of expert anticipation.

Our findings indicated that psychological factors such as resilience, arousal regulation, leadership and communication, and sports intelligence are important for anticipation. Accordingly, there appears to be an increased need to focus on the fields of sport expertise and sport psychology when assessing and training key factors that contribute to superior performance in sport (Müller et al., 2019; Williams & Jackson, 2019). There are three reasons to further justify this position. First, there continues to be a greater focus upon the physical or physiological components of sport performance, rather than incorporation of psycho-perceptual-motor skill, even though the latter is considered key to differentiating superior performance in sport (Johnston, Wattie, Schorer, & Baker, 2018; Steel, Harris, Baxter, King, & Ellam, 2014). Second, literature indicates that performing under pressure can heighten psychological factors such as anxiety, which can impede anticipation (Cocks et al., 2016). This is a major concern because, for example, saving the drag-flick can impact whether a team wins or loses a game. Third, there is a growing body of literature that

indicates training anticipation along with arousal regulation under simulated anxiety conditions can improve anticipation, which transfers to improvement on field-based tests (Alder et al., 2016). Therefore, an interdisciplinary approach comprising sport psychology and expertise can ensure that athletic performance is thoroughly assessed and improved.

From a practical perspective, the findings from this study provide several implications to assess and train anticipation. First, due to the lack of opportunity to face a variety of different styles of drag-flickers in practice, goalkeepers' focus may overtly shift to ball flight. Video-based temporal occlusion can be used to measure pick-up of contextual (e.g., defensive runner or drag-flicker action preferences) and kinematic information to anticipate (Aglioti, Cesari, Romani, & Urgesi, 2008; Balser et al., 2014; Runswick, Roca, Williams, McRobert, et al., 2018; M. J. Wright & Bishop, 2019). Second, potential over-reliance on ball flight can be overcome by video-based temporal occlusion training, that presents in-match footage of opposition drag-flickers (Müller, Brenton, & Rosalie, 2015; Müller & Rosalie, 2019). Through manipulation of stimulus duration, a goalkeeper's attention can be guided towards contextual and kinematic information without overtly reducing the value of ball flight information. Such an approach offers a time efficient manner to train anticipation during training or at home, which is important due to athletes' busy schedules. Third, virtual reality (VR), which is becoming increasingly popular to train sports skills, could be used with in-match footage of penalty corner drag-flicks so that participants can practice the pick-up of advance cues and early ball flight information and respond with a simulated movement response. Further research, however, is needed to verify pick-up of contextual, kinematic, and ball flight information using VR, before it can be used as a training tool (Miles, Pop, Watt, Lawrence, & John, 2012). Fourth, coaches could use a constraints-based practice approach to create game-based scenarios, which include contextual (e.g., positioning of drag-flickers around the penalty circle) and kinematic information (i.e., drag-flickers movement pattern),

but with deflected shots mid-flight on some trials (Chow, Davids, Button, & Renshaw, 2016). Such an approach may encourage goalkeepers to attend to advance cue and ball flight information, which participants believe is important for performance. Finally, psychological interventions targeted at optimizing arousal regulation, such as forms of stress exposure training, could facilitate goalkeepers' ability to anticipate under match pressure (Alder et al., 2016; van Rens, Burgin, & Morris-Binelli, 2020).

Although this study provides detailed insight into the attitudes and beliefs of elite field hockey goalkeepers and coaches, some limitations need to be addressed. First, our sample comprised one country's national program. A sample that includes elite goalkeepers and coaches from high-performance centers in other nations, as well as elite goalkeepers and coaches from different sports with similar temporal constraints, but different game contexts, for example soccer, may provide additional perspectives on how to anticipate. Second, semi-structured interviews focus only upon what is believed to be conscious pick-up of visual information for anticipation (Smith & Sparkes, 2016). This does not take into consideration sub-conscious pick-up of information, which has been reported to be a key discriminator of expertise (Abernethy & Russell, 1987). To this, what athletes and coaches consciously believe as important to accelerate expertise, can determine investment of time to improve an athlete's sub-conscious skill development (Müller et al., 2019). As such, a mixed method approach wherein qualitative and quantitative evidence of anticipation is compared can provide unique opportunity to inform coaches and athletes of evidence-based skill development practice.

In this study we have reported that elite goalkeepers and coaches place considerable value on visual cues from contextual, the drag-flickers action occurring prior to ball flight, as well as ball flight information for saving the shot on goal. The capability to pick-up these visual cues is believed to be integrated with motor execution and psychological factors that

675 can prepare the athlete to save the shot on goal. These findings build on the theoretical
676 understanding of how athletes integrate perceptual, psychological, and motor components of
677 skills for anticipation in a highly complex high-speed interceptive sport skill. Further, the
678 findings presented in this study may be transferrable across other high-speed interceptive
679 sports by guiding the practices of coaches and high-performance programs, as well as
680 developmental programs (i.e., talent identification and training at state and junior levels).
681 Specifically, content of this paper may provide a useful framework to assess athletes and
682 coaches' thoughts regarding their skills, and then follow-up with measures of actual
683 performance (i.e., laboratory, in-situ field or match settings), to guide the design of practice
684 tasks for improvement of athletic performance through an interdisciplinary approach. In
685 doing so, development programs across the skill continuum may better prepare their athletes
686 for higher levels of performance.

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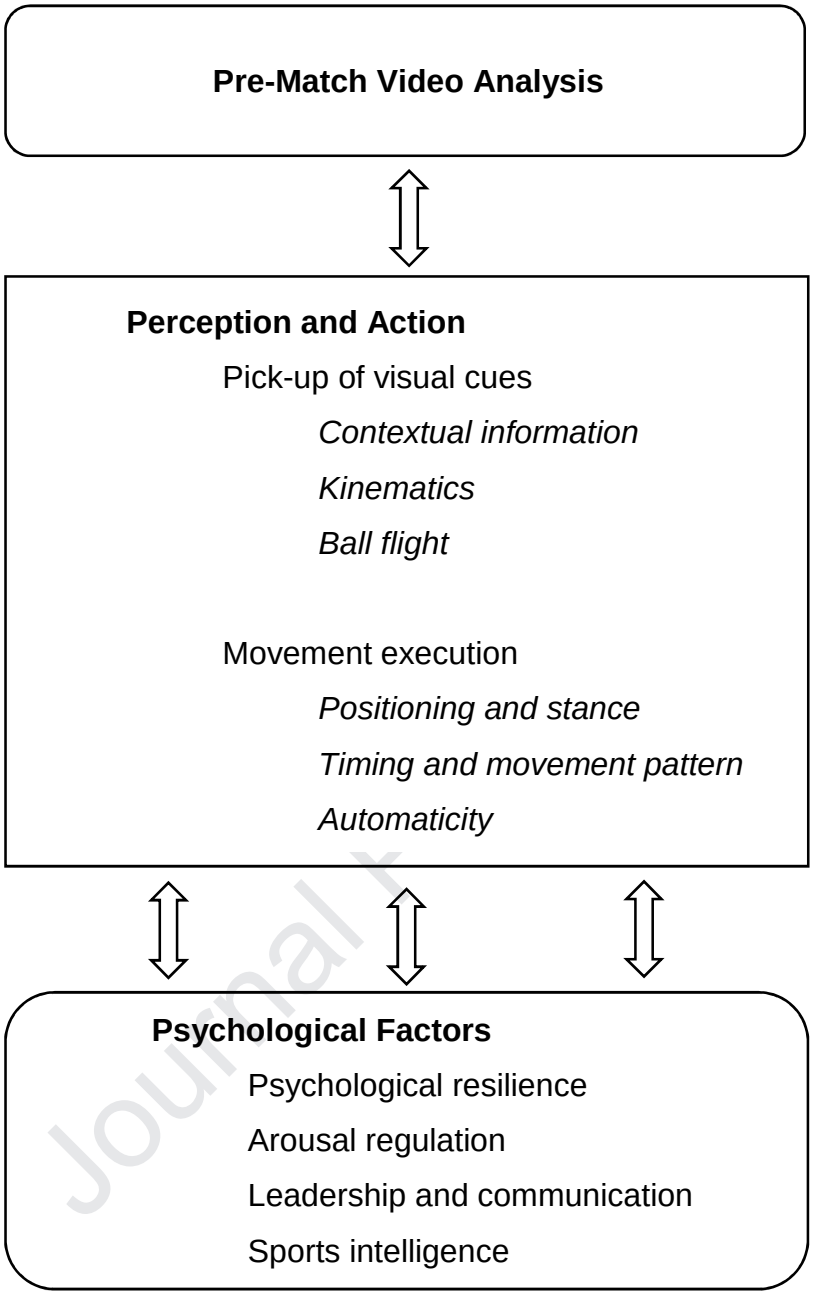

Figure 1. Goalkeepers and coaches' beliefs and attitudes of factors related to anticipation of the drag-flick within penalty corners.

Highlights

- Psycho-perceptual-motor factors such as anticipation is vital to save a drag-flick
- Pre-match video analysis is deemed important for goalkeepers' preparation
- The pick-up of visual cues and movement execution are key to save a drag-flick
- Psychological factors are thought to affect penalty corner saving performance
- An interdisciplinary approach is recommended to investigate sport performance

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: