Psychology of Sport and Exercise 15 (2014) 260–267

Contents lists available at ScienceDirect

Psychology of Sport and Exercise

journal homepage: www.elsevier.com/locate/psychsport

Skill differences in visual anticipation of type of throw in team-handball penalties

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ARTICLE INFO

Article history:
Received 17 July 2013
Received in revised form
20 January 2014
Accepted 21 January 2014
Available online 8 February 2014

Keywords:
Perceptual-cognitive expertise
Information pick-up
Temporal occlusion
Spatial occlusion

ABSTRACT

Objectives: Visual identification and anticipation of an opponent's action intentions is crucial for successful performance in interactive situations such as team-handball penalties. We conducted two experiments to examine experienced and novice team-handball goalkeepers' ability to predict the type of throw in handball penalties and to identify the observers' reliance on local versus globally distributed spatial cues.

Design and methods: In Experiment 1, following a 2 (Skill) × 5 (Temporal Occlusion Condition) factorial design participants were provided with videos of team-handball penalties where the amount of viewing time was varied. In Experiment 2, another sample of experienced and novice goalkeepers watched videos of spatially manipulated penalties where specific parts of the thrower's body or the ball were either removed or presented in isolation (2 [Skill] × 9 [Display Condition] factorial design).

Results: In Experiment 1, experienced goalkeepers outperformed novices and both groups similarly improved their performances with later occlusion conditions. In Experiment 2, experienced goalkeepers were again superior to novices, and local cues (e.g., ball and hand) were sufficient for better than chance predictions in both groups. Moreover, experienced in contrast to novice goalkeepers (i) suffered from the removal of and (ii) benefited from the addition of distal (i.e., throwing arm and ball) as well as proximal (i.e., upper body) kinematic features.

Conclusions: Our research is in line with previous findings on perceptual-cognitive expertise in sports and suggests that experienced team-handball goalkeepers rely on multiple, globally distributed cues when making anticipatory judgments.

Introduction

Athletes face considerable spatiotemporal constraints in many dynamic sporting interactions. To counteract the time pressure and its potential costs for sport performance (e.g., inaccurate or late execution of a motor skill) athletes need to anticipate future events to guide well-timed motor (re)actions (Müller & Abernethy, 2012; Yarrow, Brown, & Krakauer, 2009). For example, in team-handball or soccer penalties, high ball speeds in combination with close distances between the shooter and the goalkeeper (e.g., 7 m in team-handball) make it almost impossible for goalkeepers to intercept the ball when starting a defensive action after ball flight is visible (Dicks, Davids, & Button, 2010; Schorer & Baker, 2009). Consequently, to preserve the chance of successful ball interception goalkeepers need to initiate their defence based on the anticipated shooter's intention prior to the moment of ball projection (Gutierrez-Davila, Rojas, Ortega, Campos, & Parraga, 2011).

Previous research has consistently demonstrated an expert advantage at predicting an opponent's action outcome (for a meta-analysis, see Mann, Williams, Ward, & Janelle, 2007). Skill-related differences were found in various sporting domains including tennis (Goulet, Bard, & Fleury, 1989), badminton (Abernethy & Russell, 1987; Abernethy & Zawi, 2007), volleyball (Loffing, Schorer, Hagemann, & Baker, 2012), soccer (Williams & Burwitz, 1993), cricket (Müller, Abernethy, & Farrow, 2006) and handball (Cañal-Bruland, van der Kamp, & van Kesteren, 2010). In addition, differences are evident across various perceptual tasks such as the prediction of ball flight direction (e.g., Abernethy & Zawi, 2007; Loffing et al., 2012; Williams & Burwitz, 1993), the identification of type of shot (e.g., in the tennis serve; Goulet et al., 1989) and the detection of deceptive actions (Cañal-Bruland et al., 2010; Jackson,

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http://dx.doi.org/10.1016/j.psychsport.2014.01.006
1469-0292/

Warren, & Abernethy, 2006). The skill effect appears most pronounced when predictions are based on an opponent's early (e.g., before the moment of ball projection) as opposed to late (e.g., moment of or after ball projection) movement information (Loffing et al., 2012; Müller et al., 2006; Williams & Burwitz, 1993), suggesting that skilled athletes are more capable to use advanced kinematic cues for anticipatory judgments. However, there is inconsistent evidence as to the range of cues (i.e., local versus globally distributed) that skilled versus less skilled athletes are likely to benefit from and integrate into their judgments. While in badminton or cricket local distal cues such as the racket (e.g., Abernethy & Zawi, 2007) or the bowling hand (e.g., Müller, et al., 2006) respectively appear relevant, in tennis skilled performers in contrast to their less skilled counterparts seem to rely on information emanating from multiple, globally distributed cues such as the arm and the racket (distal) as well as the shoulder or the hips (proximal) (Huys et al., 2009; Williams, Huys, Cañal-Bruland, & Hagemann, 2009).

In team-handball penalties, besides predicting ball flight direction (Schorer & Baker, 2009; Schorer, Loffing, Hagemann, & Baker, 2012) or detecting whether a shooter is about to make a shot or not (Cañal-Bruland & Schmidt, 2009; Cañal-Bruland et al., 2010), goalkeepers are also required to identify the type of throw (i.e., hard versus lobbed shot). The latter task results from goalkeepers making frequent use of a rule which allows them to move within 3 m to the penalty-taker. While positioning themselves between the penalty-taker and the goal line allows goalkeepers to enlarge the projected goal area covered by their body, it also makes them prone to being lobbed. Therefore, in such situations goalkeepers have to detect early if a penalty-taker will deliver a hard shot towards one of the four corners of a goal or if he or she will lift the ball above the goalkeeper.

We carried out two video-based experiments to investigate, first, if experienced team-handball goalkeepers are more efficient than novices at integrating a varying amount of an opponent's advance throwing kinematics into the identification of type of throw (Experiment 1). Second, we sought to examine if experienced and novice goalkeepers differ in the ability to make efficient use of local (e.g., the ball) and globally distributed spatial cues (e.g., a combination of distal and proximal cues) provided by a penalty-taker's movement (Experiment 2).

Experiment 1

An efficient pick-up and interpretation of early movement cues help to preserve the chances of successful interception in handball goalkeeping (Gutierrez-Davila et al., 2011). A classical approach for studying *when* in the course of an opponent's action an effective information pick-up for anticipation occurs and how the provision of more information affects perceptual judgments is to apply the *progressive temporal occlusion paradigm* (Abernethy, 1987). Application of this paradigm means that an opponent's action, usually viewed from another player's standard on-court perspective (e.g., penalty-throws viewed from a team-handball goalkeeper's perspective), is presented using differing predefined time points such that observers are provided with a varying amount of movement information (e.g., occlusion at ball release or some milliseconds before/after this event). Previous work has demonstrated that prediction performance improves with later occlusion conditions and that skill differences are most evident when observers are required to make predictions based on early stages of an opponent's action (e.g., before the ball is released). This skill effect reduces and almost vanishes with later occlusion conditions (e.g., Abernethy & Russell, 1987; Abernethy & Zawi, 2007; Loffing et al., 2012; Williams & Burwitz, 1993).

In Experiment 1, we sought to identify whether experienced and novice goalkeepers differ in their ability to predict the type of throw in team-handball penalties as well as whether these groups are affected differently by variation in the amount of movement information. In light of previous research we hypothesized that (i) experienced goalkeepers would significantly outperform novices (e.g., Cañal-Bruland & Schmidt, 2009; Cañal-Bruland et al., 2010; Savelsbergh, Williams, van der Kamp, & Ward, 2002), (ii) performance would significantly increase with later temporal occlusion condition (e.g., Jackson, et al., 2006; Müller et al., 2006) and (iii) the skill effect would be most pronounced at early (e.g., pre ball release) compared to late occlusion conditions (e.g., Loffing, et al., 2012; Williams & Burwitz, 1993).

Method

Participants

Fourteen team-handball goalkeepers who played in the highest to fifth highest league in Germany at the time of testing (age: $M = 24.64$ years, $SD = 5.5$ years; handball experience: $M = 16.14$ years, $SD = 4.85$ years; five females) and 23 novices (age: $M = 24.87$ years, $SD = 3.67$ years; no playing experience in team-handball or in goalkeeping in other structurally related sports; six females) voluntarily took part in the experiment. All participants were naïve as to the purpose of the experiment, reported normal or corrected-to-normal vision and provided written informed consent prior to the beginning of testing.[2] The study was conducted in accordance with the Revised Declaration of Helsinki (as of November 2008).

Apparatus and stimuli

We recorded three right-handed male team-handball players performing 7 m penalty throws towards a regular team-handball goal. The actions were recorded from a goalkeeper's perspective with a digital camera (SONY HDR-FX1000E) at a resolution of 25 frames per second. The camera was mounted on a tripod which was positioned 1.5 m in front of the goal centrally between the left and right goal posts at a height of 1.65 m. The camera was not positioned on the goal line, first, because team-handball goalkeepers usually also stand nearer to the shooter and not on the goal line when awaiting penalties and second, because we asked the players to perform hard and lobbed shots. While hard shots are characterized by high ball speeds and can be used irrespective of a goalkeeper's position, lobbed shots have considerably lower speeds and are only used when a goalkeeper is positioned in front of a goal. Lobbed shots are characterized by the ball being lifted (i.e., the ball rolls off a thrower's hand) above a goalkeeper who, during the recordings, was represented by the camera. Hard shots were directed to one of the four corners of a goal and lobbed shots were placed in the centre of the goal below the crossbar. Players were instructed to perform the shots as if they were confronted with a real goalkeeper.

Out of the recording material we chose two of the three players each with four different lobbed and hard shots for the creation of experimental stimuli. One lobbed and one hard shot of the third player was selected for familiarization trials. For the hard shots, we ensured that each of the four shots was directed to one of the four corners of a goal. We used the video software *Adobe Premiere Pro CS4* to create five different time-points at which the penalties stopped. The actions were temporally occluded either at the

[2] In Experiment 1, we tested 24 novices but excluded one male participant from the analyses because after completion of the experiment he reported to have non-corrected vision impairment.