Journal of Human Kinetics volume 70/2019, 235-243 DOI: 10.2478/hukin-2019-0042
Section IV – Behavioural Sciences in Sport

DE GRUYTER OPEN

Handball Goalkeeper Intuitive Decision-Making: A Naturalistic Case Study

by
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Goalkeepers hold a key position for success in team sports competitions. They perform in dynamical contexts and are highly submitted to time pressure. The purpose of this naturalistic case study, therefore, was to explore how a handball expert goalkeeper deals with the uncertainty of the competition settings to make successful decisions. An individual self-confrontation interview was held with a goalkeeper while he watched duels with potential throwers in an official competition. A mixed method was used combining the first-person and third-person point of view. Verbal data were supplemented by observational data (distance measures between the goalkeeper and the potential thrower) in 83 short accounts of decision-making situations. Qualitative analysis resulted in 419 units of salient features, in three types of processes related to the Recognition-Primed Decision model, and in four micro-decisions. Non-parametrical statistical analysis indicated that there was a significant effect of distances between the potential thrower and the goalkeeper, on the micro-decision categories, but not on the recognition processes. These results provide insights into cognitive contents and processes an expert goalkeeper can use under uncertainty and time pressure. The mixed method furnishes a meaningful description and a subsequent understanding of expert performances in sport.

Key words: *recognition processes, goalkeeping performance, elite, team sport, competition.*

Introduction

Recently intuitive decision-making (i.e. decision made very quickly due to experience) began to be studied in different team sport settings (e.g., handball: Johnson and Raab, 2003; soccer refereeing: Schweizer et al., 2011; rugby coaching: Collins et al., 2016), because team sport performances require decisions and actions in dynamic situations (i.e., complexity to predict opponents' actions in fields that can be inter-penetrated, scoring evolution among time, influence of previous actions on the present moment, players substitutions). In ergonomics, using a naturalistic decision-making (NDM) approach, Klein (1998, 2008, 2015) has contributed to improving the understanding of how experts make choices in military, nuclear power, aviation, human management, and economics. In the NDM framework, the Recognition-Primed Decision (RPD) model is an alternative to the rationalistic linear information-processing model because in dynamic situations experts do not make decisions based on rational deductions or exhaustive analyses of expectancies (Klein, 1998). On the contrary, experts use their experiences to drive their perceptions onto salient features, to recognize situations as familiar or typical, and to make intuitive and adaptive decisions. Thus they use few patterns or options they have learned to

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Authors submitted their contribution to the article to the editorial board.
Accepted for printing in the Journal of Human Kinetics vol. 70/2019 in December 2019.

make rapid decisions (Kermarrec and Bossard, 2014). The RPD model (Klein, 1998) suggests three levels of experiencing a complex situation: simple matching, simulating a course of action, and diagnosing the situation. Simple matching is made when the situation is quickly perceived as familiar. The expert deals with complexity by coupling very few cues to an action or sequence of actions. Simulating a course of action is done when an expert perceives the situation as familiar and when time pressure is not high. He/She simulates a few options to implement through mental visualization until he/she gets the one that appears appropriate to the situation. This process allows him/her to imagine the effectiveness of the option in the current situation. Diagnosis occurs when the situation is perceived to be incongruous, non-familiar to the expert. To deal with situation uncertainty, the expert must clarify it by diagnosing the situation, focusing on its similarities with previous experienced cases and hereby choosing an appropriate action.

The RPD model started to be applied also in sport settings over the last years (e.g., Kermarrec and Bossard, 2014; Macquet, 2009; Mulligan et al., 2012; Neville et al., 2017) using the first-person approach to highlight how previous experiences organized the players' perception of one situation, and to bring new and complimentary empirical evidence on the way experts use surrounding information to support ongoing decisions and actions.

Bossard et al. (2010) and Macquet (2009) brought empirical evidence to complement Klein's four salient features categories: in an on-going situation, sport players take in account a plausible goal (e.g. "I wanted to intercept the ball"), relevant cues or information (e.g. "a curve trajectory"), expectancies (e.g. "I was expecting a hit"), the course of action (e.g. "I've to move forward"), consequences of a course of action (e.g. "I can only push the ball in front of me"), and knowledge (e.g. "I know he is right-handed").

Salient features constitute properties of the situation that can lead experts to recognize the situations as familiar or unfamiliar. Previous qualitative studies investigated the recognition processes team sport experts used, in Australian Football (Neville et al., 2017), volleyball (Macquet, 2009), soccer (Kermarrec and Bossard, 2014), and ice hockey (Bossard et al., 2010; Mulligan et al., 2012). At least 80% of the experts' decisions were classified as simple-matching, which is consistent with the results of Klein' studies in work fields. About 15% of the experts' decisions were related to diagnosis, which can be related to players' expertise (i.e., few situations were assessed as non-familiar). Less than 5% were related to simulate, which can be explained by time pressure within the game. Nevertheless, Kermarrec and Bossard (2014) focused on the decisions soccer players made during 118 defending situations. Only 60% of the decisions (n = 68) were made using a simple match, whereas 23% (n = 26) of the decisions required a simulation process, and 16% (n = 18) of the decisions were taken using diagnosing the situation.

The authors explained that the relatively high proportion of simulating processes compared to other studies in team sport settings could be related to the status of the participants. Defenders have more time than attackers to simulate alternate courses of action and modify existing decision actions. Complementary findings highlighted the salient features the players used to make their decision. For example, when a defender elicited that he was far enough to the ball, he tended to take time to diagnose or to simulate the situation. The authors suggested that distances from the ball were relevant cues for making decision especially at defensive stages. Based on Klein's assumptions (Klein, 2008), they claimed that spatiotemporal configuration led defenders to "the feeling of urgency", and that the defenders assessed the urgency of situation through their own distances from the ball carrier. Nevertheless, in this study, spatiotemporal constraints were identified only from the participants' point of view, and distances were not objectively measured.

Thus, these empirical studies have investigated decision-making from a qualitative first-person approach. Although the relevant results were brought in, it could be relevant to distinguish between different levels of uncertainty and complexity of a situation (i.e., with objective facts and how athletes value them) to better understand the coupling between an athlete and sport constraints. Furthermore, previous research used joint first and third person approaches to study expertise in sport. For example, sport researchers (Hauw et al., 2017; Poizat et al., 2010; R'Kiouak et al., 2016) described athletes'

experiences of using both the first-person approach (i.e., athletes' inner experiences) and the third-person approach (e.g., biomechanical, kinematic data). As such, a combination of the first- and third-person approaches could provide complementary information to deeply understand expert performance and decision-making.

Handball goalkeepers' performance is obviously submitted to the characteristics of dynamical situations defined by the NDM framework, and it is relevant to examine how recognition processes are influenced by player status, uncertainty and time-pressure. Handball goalkeepers' successful actions are to block balls thrown by opponents or to force them to throw to the free zone. Most of the time, they have to face complex situations: they have to place a part of their body at the right place at the right moment, despite the high speed of the throw and the uncertainty of the ending location of the ball direction, because the player can make it change during his throwing action. Studies conducted in experimental settings stated the medium speed of the throws during the 2013 Men's World Handball Championship reached 22 m/s (Cortés et al., 2017), and showed that goalkeepers initiated their movement while the thrower still had the ball in his hands, respectively 43 ms (as a mean) and 193 ± 67 ms before the release of the ball (Gutierrez-Davila et al., 2017). This strategy was related to visual and anticipatory strategies which aimed to perceive relevant features in a situation and to predict future actions based on the movement of other players to reduce uncertainty and time-pressure (Debanne, 2003; Gutierrez-Davila et al., 2017; Rivilla-García et al., 2013).

This case study therefore aimed to identify the recognition processes and the relevant information cues leading to intuitive decision that an expert handball goalkeeper made in a competitive setting. We hypothesized that the distance between the goalkeeper and the thrower would be the main feature to assess how complex a situation was. Furthermore, in order to study such complex situations, we combined observational data from the external/third-person viewpoint such as distances from the goalkeeper to the carrier of the ball, and verbal data from the internal/first-person viewpoint.

Methods

Participant

To participate in this study, the goalkeeper had to be an elite handball athlete. As the international community of handball high-level coaches, trainers and players considers French goalkeepers to be the best in the world, we contacted clubs to find a goalkeeper who: 1) had more than 10 years of experience, 2) currently played in the best French league, and 3) competed in the European Champions League. We presented the study to managers and then to the coaches who expressed interest. One coach and his goalkeeper willingly accepted to participate. He (we will call him Bastian to preserve his anonymity), was 34 years old, had competed in the highest French league for 12 years, and currently participated in the European Champions League.

Material and measures

Observational and verbal data were gathered on two phases.

First, we recorded the match from two locations: the first high definition camera was positioned in upper stadium stands, behind the goalkeeper. It was set for a fixed and wide-angle shot, and recorded every action of the match. The second high definition camera was positioned on the highest stadium stands. Its wide-angle view provided a fixed shot of what happened on the whole field. Then, the main researcher carefully viewed the video recorded from behind the goalkeeper in order to select a row of shot sequences from the first and the second period to show them thereafter to the participant. Two criteria defined a shot sequence: (a) the sequence began with the loss of the ball by the team and/or ball recovered by an opponent, and (b) ended with the opponents' loss of the ball, granted by the referees (i.e. save from the goalkeeper or goal scored by the thrower). To limit the length of the interview and to avoid a loss of information the goalkeeper could provide because of a repetitive commenting task, only 26 shot sequences were selected before the interview was organized. They reported a wide range of defensive situations (i.e., organized defense around the 6 and 9 m lines, penalties, defensive fallback on counterattacks, facing long and close shots, jump shots and running shots) and in different moments of the entire match. The selection was then assessed and validated by the second researcher. Each situation

lasted between 3 and 28 s.

The second phase consisted of verbal data collected during a video-cued recall interview (e.g., Kermarrec and Bossard, 2014; Macquet, 2009). The method of this interview provides access to the inner experiences of people. It is similar to the auto-confrontation interview (e.g., Poizat et al., 2010) and to the Critical Decision Method (CDM) developed to investigate experts' decisions in naturalistic settings (Klein et al., 1989). This interview was supported by a formal contract of cooperation between the goalkeeper and the researcher. It was conducted on the morning the day after the match by the main researcher and lasted 45 minutes. The interview was entirely recorded, using a digital video camera and a tape recorder. At the beginning of the interview, the researcher told the goalkeeper "During every shot sequences you'll see, I would like you to stop the video at any time you felt some 'urgency to act' yesterday, and to tell me what information led you to feel that. After that, I would like you to explain how this information led you to act". As the goalkeeper viewed the video footage, the researcher encouraged him to comment as precisely as possible on his actions and the events leading up to the decision. The interviewer's prompts were related to the description of actions, thoughts, feelings and events as experienced by the goalkeeper before, during and after each critical decision. According to RPD model decision–making is a recognition process. Thus, the recall process was facilitated using questions about attempts (what are you looking for?), focus (what is drawing your attention?), intentions (what do you want to do?), and thoughts (what are you thinking about?) associated with each decision.

Data Processing

Two materials were analyzed: the recording of the interview for the content analysis, and the video recorded on the highest stadium stands during the match for calculating distances.

The recording of the conversation between the goalkeeper and the researcher was fully transcribed. These verbal data were processed in five steps: (a) generating shot sequences logs, (b) selecting and identifying decision-making salient features, (c) identifying the recognition process, (d) identifying the content of decision-making, (e) ensuring validity of generated categories, (f) combining observational and verbal data. Such qualitative analysis has been used by other researchers in order to study decision-making in naturalistic settings (Kermarrec and Bossard, 2014; Macquet, 2009).

Generating shot sequences logs: This first step consisted of generating a summary table or log of the sectioned data for each of the 26 shot sequences. The main objective of this table was to prepare the data for subsequent content analysis. Spatiotemporal terms reported by the goalkeeper (e.g. "then", "now", "here") helped the researchers to define the beginning and the end of several short accounts (i.e. successive situations the goalkeeper assessed) within the 26 shot sequences. Descriptions of goalkeeper's actions and comments were placed side-by-side in a table for each shot sequence: the first column referenced the time at which the sequence occurred. The second column described the face-to-face contact between the goalkeeper and the potential thrower. The third column reported the goalkeeper's verbalization.

Selecting and identifying decision-making salient features: The second phase consisted of selecting data related to goalkeeper's decision-making. We used a category system derived from the RPD model (Klein, 2008) and from Macquet (2009) and Bossard et al. (2010) in order to code the salient features of decision-making. Goalkeeper's discourse enabled us to identify his goals and the recalled knowledge, the actions he has chosen, what he could expect and, which consequences of his actions he has observed. We attributed a code for each of the salient features: plausible goals (G), relevant cues or information (I), expectancies (E), action (A), knowledge (K), or consequences of a course of action (C). The following example presents one short account composed by three salient features: "Here I see that the ball was on the right side (I), the attacker kicks a long pass to the central back (I); I think he can shoot (E)". The present example let us know that the goalkeeper assessed the situation in order to identify a potential thrower. Considering the 26 shot sequences, we found 419 units of salient features and 83 short accounts, which corresponded to 83 decision-making instances.

Identifying recognition processes: We conducted a theoretical content analysis referring to the RPD model (simple match, diagnose and simulate). Based on the previous coding (i.e. salient features of decision making), we looked for

processes within the specific mechanisms the goalkeeper used to assess successive situations and to make decisions. We analyzed verbal reports about each short account separately and classified them into three categories of processes (the three levels of the RPD model).

We used language register features. Such features come from linguistic classes, including phonological features (pauses, intonation patterns), specialized verb classes (speech act verbs, mental process verbs), and lexical classes (uncertainty, urgency feeling, well-known, security, familiarity). Previous studies using the RPD model in sport (Bossard et al., 2010; Macquet 2009; Mulligan et al., 2012) agreed to consider that if the situations were assessed as familiar, simple match and simulate would be typical processes of decision-making. Alternatively, if the situation was uncertain, diagnosis should be used (Figure 1). Thus, in verbal reports, researchers looked for linguistic items revealing the experience of the situations the goalkeeper encountered.

Consequently, we looked for verb forms and lexical classes, which expressed a familiar setting, *versus* uncertainty, an unfamiliar setting. To differentiate between simple match and simulate, we looked for linguistic features expressing whether situation assessment was quickly provided or not. For example, "I immediately see his race coming to the central area (I), so I take a step forward (A)" reported a well-known situation, and a quick consideration of a salient feature that brought a rapid option ("immediately") and was consequently related to a simple matching process. In the second example, "I know he is left-handed (K), he holds the ball on his left side (I), his race will lead him like that (E), so I offset a bit of my goal line (A) but not too much, I don't want to open the left area (G)", the end of the situation is well-known, and the assessment occurs after the consideration of knowledge (K) and expectation (E), furthermore, achievement is evaluated ("a bit", "too much"). According to the RPD model, those features led us to consider that the decision-making process implicated here was simulation.

. *Identifying the content of decision-making:* In this step, three researchers proceeded to an inductive categorization (Strauss and Corbin, 1998) of the verbal data. Two of them had already coded qualitative data in previous studies in team sport and were familiar with the RPD model. They individually analysed the interview transcription and identified the content of the 83 decision-making instances. In this step, only the portion of participant's verbalization related to what decision he made was considered. Within such portions of data, we obtained 83 meaningful units describing the decision-making contents. Each unit of meaning had to be consistent with the action performed that the goalkeeper was commenting on (Feigean et al., 2018). Then, the researchers gathered together units of meaning that shared similarities in order to identify typical contents of goalkeeper's decisions (Kermarrec et al., 2014). This step of the procedure included the specific work of naming typical categories, respecting the participant's experience of the situation. Four typical categories finally emerged from the analysis.

Ensuring validity of generated categories (i.e., contents of decision-making and recognition processes): the researchers compared their respective results in order to validate theoretical (i.e., the salient features and the recognition process) and empirical (i.e., the content of decision-making) categorizations. The inter-rater reliability of the coding procedure was assessed using the percentage of agreement, which is defined as the number of agreements between observers in assigning cases or events in descriptive categories divided by the sum of both agreements and disagreements, and then multiplied by 100 to yield a percentage. The initial agreement rate was 85% for salient features coding, 95% for types of the recognition process and 95% for the content of decision-making. When researchers did not agree, they discussed until finding a consensus.

Combining observational and verbal data: the distances' measure method was inspired by the manual video tracking method for sports performance analysis (Duarte et al., 2010). Virtual distance data (i.e., pixels) were transformed into world pitch distances (i.e., meters and centimeters). A calibration was built on the field's reference marks acting as control points. Seven distances separating two field elements were calculated to ensure the calibration. These distances were associated with each categories issued from content analysis of the goalkeeper's inner experience (i.e. recognition processes and contents of decision-making).

Statistical analysis

Statistical analysis was performed using SPSS (SPSS, version 21.00, Inc., Chicago, IL, USA). Preliminary analysis of descriptive statistics (i.e. means, and standard deviations) and the Shapiro-Wilk normality test indicated that the data were not normally distributed ($W = .780$, $p < .01$). Thus, a Kruskal-Wallis H test was used to compare distances depending on each categorical data. The level of significance was determined at ≤ 0.05.

Results

The behaviors and verbal reports from the 26 shot sequences generated 419 units of salient features and 83 short accounts of decision-making situations. Content analysis permitted to highlight which information was picked, the content of decision-making and the recognition processes the goalkeeper used. Data are presented in three stages: the salient features, the recognition processes and the typical contents of decision-making experienced by the goalkeeper.

Salient features from the goalkeeper's point of view

As in previous research of expert decision-making processes in sports with the RPD model (Bossard et al., 2010; Kermarrec and Bossard, 2014; Macquet, 2009), we used a six-categories coding scheme to classify units of meaning (Table 1).

Recognition processes experienced by an expert handball goalkeeper

Thematic analysis was conducted in reference to the RPD model (Figure 1). Considering the content of relevant features, specific mechanisms expressed by the participant, and the constraints of the situations, 83 short accounts of decision-making situations were classified into three types of processes (Table 2).

When the goalkeeper experienced the simple match recognition process, he immediately connected relevant cues to action (i.e., perception to action). This was particularly true when the goalkeeper was very close to the thrower and constrained to act very quickly against him. When the goalkeeper used the simulation recognition process, he imagined the on-going course of action, and took time to assess his first option. Sometimes data showed the goalkeeper was not simulating his own action, but the action of his opponent. In the given example, the goalkeeper assessed the situation considering the action capabilities of his opponent in relation to his own capabilities and anticipated the future course of action. When he relied on the diagnosis recognition process, the goalkeeper assessed the situation as uncertain; he was not sure his first option was the better one and waited for relevant information to confirm it.

Complementary, each recognition process was associated with distances between the goalkeeper and the potential thrower (Table 2). The Kruskal-Wallis H test showed that there was no significant difference in distance between the different recognition processes categories, $\chi^2(2) = 1.044$, $p = 0.593$, with a mean rank distance of 41.51 for a simple match, 39.59 for simulate, and 47.06 for diagnosis. This finding indicated that the distances from the goalkeeper to the potential thrower had no significant influence on the recognition processes the goalkeeper used.

Decision-making contents experienced by an expert handball goalkeeper

The present study attempted to consider contents regarding the dynamics of decision-making. First, we analyzed the verbal reports to define the decision the goalkeeper made in the 83 short accounts of decision-making situations; secondly, we made an inductive content categorization of the 83 units of meaning. The analysis resulted in four typical contents: identification of the thrower; identification of the area reachable by the thrower; identification of the end of the shoot direction; identification of the appropriate standing position. For example, "He is up to shoot" referred to the goalkeeper's decision to focus his attention on the identification of the thrower (29 short accounts), whereas "between legs" and "down on my left" were related to the end of the shoot direction (20 short accounts). Noting that these typical contents were parts of a whole decision-making process during a single course of action, we called them micro-decisions. Complementary, each micro-decision was associated to the distances between the goalkeeper and the potential thrower. The combination of first- and third-person data resulted in: "identifying the appropriate standing position", 11.61 ± 11.26 m; "identifying the thrower", 10.42 ± 5.13 m; "identifying the area reachable by the thrower", 6.03 ± 2.38 m; "identifying the end of the shoot direction", 5.52 ± 2.79 m. The Kruskal-Wallis H test showed that there was a statistically significant difference in distances between the

different micro-decision categories, $\chi^2(3) = 26.53$, $p = 0.00$, with a mean rank distance of 42.92 for identifying the appropriate standing position, 60.02 for identifying the thrower, 32.68 for identifying the area, and 28.65 for identifying the shoot direction. This finding indicated that the distance between the goalkeeper and the potential thrower (as the one contextual feature) could have a significant influence on the content of the decisions he successively made.

Table 1

RPD model coding scheme and classification of total units of meaning

Categories	Definition	Units of meaning
Relevant cues (I)	Pieces of information taken into account	185 (44%)
Plausible goals (G)	Possible options, solutions that could be implemented	16 (4%)
Actions (A)	Participant's own actions, observable	74 (18%)
Expectancies (E)	Expectations about an opponent's action, the end of the ongoing situation, or to actions the participant wished to provoke	93 (22%)
Knowledge (K)	Permanent tactical defensive rules, knowledge about opponents' preferred ways to act	43 (10%)
Consequences of the course of action (C)	Assessment of the on-going situation (achievement or failure)	8 (2%)

Note: Numbers into brackets represent the percentage of total units of meaning

Table 2

Classification of short accounts of situations according to the three recognition processes, and distances between the goalkeeper and the potential thrower

Recognition processes	Example of coded verbatim	Number of short accounts situations	Distances (in meters)
Simple Match	"Immediately I see he ends up doing his about-turn (I) I begin to move toward him (A)".	38 (46%)	7.17 ± 3.13 m
Simulation	"It's very difficult for him (K), I expect he wouldn't cross his shoot (E), Benjamin is three meters wide (I), so I anticipated on my left (A)".	28 (34%)	7.81 ± 6.06 m
Diagnosis	"I'm rather waiting for a shoot down (E) because with his movement (I), it's highly likely that he throws down (E). He doesn't put enough power to rise again (K). It could be everywhere but down (E) so I wait, feet apart (A)".	17 (20%)	9.15 ± 6.94 m

Note: Numbers into brackets represent the percentage of total short accounts situations

Table 3

Qualitative studies using RPD model in a sport setting: recognition processes frequencies

RPD model in a sport setting	Volleyball Macquet (2009)	Ice-hockey Bossard et al. (2010)	Ice-hockey Mulligan et al. (2012)	Soccer Kermarrec and Bossard (2014)	Australian Football Neville et al. (2017)	Handball Present study
Game phases	Attacking phases	Counter-attacks	Attacking phases	Defending phases	All (umpires decisions)	Goalkeeper and thrower duels
Simple Match	57/70 (81%)	46/57 (80%)		68/112 (60%)	697/887 (79%)	38/83 (46%)
Simulate	4/70 (7%)	2/57 (3%)	68/80 (85%)	26/112 (23%)	12/887 (1%)	28/83 (34%)
Diagnosis	9/70 (12%)	9/57 (17%)	16/80 (15%)	18/112 (16%)	175/887 (20%)	17/83 (20%)

Note: percentages are put into brackets

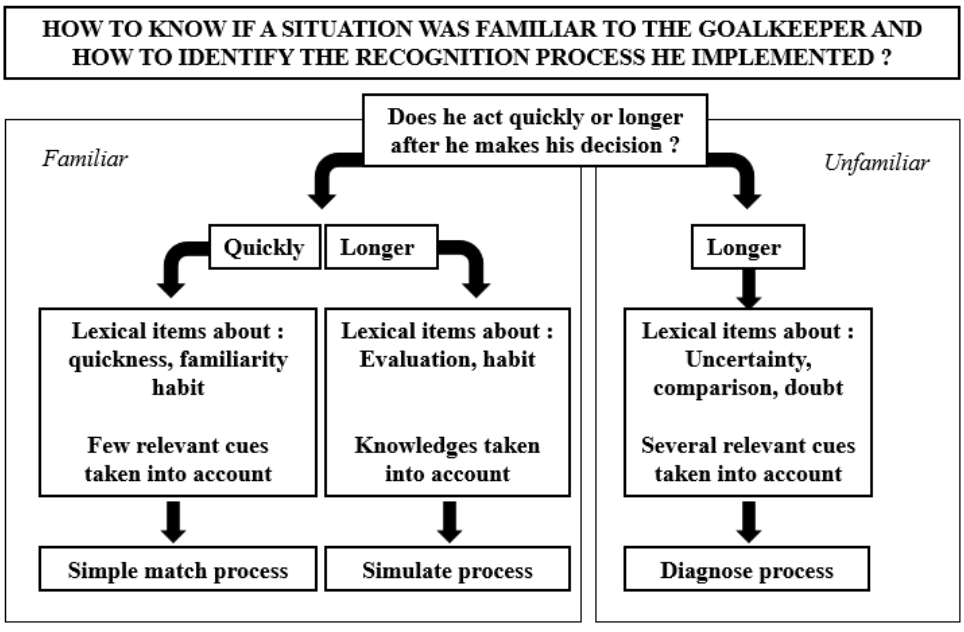

Figure 1

Content analysis and recognition processes identification

Discussion

This case study aimed to examine how an elite handball goalkeeper made decisions in a naturalistic competitive sport setting. Our results suggest that elite handball goalkeeping decision-making is based on six salient features, which can support three categories of processes related to the RPD model (Klein, 1998). Furthermore, the distance between the goalkeeper and the potential thrower seems to be a very relevant cue, which led to different types of micro-decisions.

Mechanisms underlying intuitive decision-making in team sports

The RPD model has been successfully applied in various team sport setting. Table 3 presents our findings related to recent studies using the RPD model in team sport games settings (adapted from Kermarrec and Bossard, 2014). Although our results supported that athletes adopted most of the time a simple matching process compared to a diagnosis or to a simulation process, our data are singular considering the relative low frequencies of this process (46%) compared to percentages from other studies (from 60 to 81 %, Table 3). This may probably be due to the particularity and the variety of each studied sport.

In previous studies, few decisions were made using simulation (from 3 to 23 %, Table 3). In the current study, the goalkeeper used simulating processes in 34% of the situations. These findings are in accordance with a previous study on defending phases in soccer (Kermarrec and Bossard, 2014), but diverge from other studies in team sport games involving mainly attacking phases (Bossard et al., 2010; Macquet, 2009), which could be due to each sport specificities. Thus, a potential working hypothesis for future research is to investigate whether we can generalize this notion that player status or game phases (attack vs. defense) influences the recognition processes.

Furthermore, the goalkeeper tried to evaluate the situation considering two types of simulation processes: (i) the first person simulation, in which the goalkeeper evaluated his capabilities and possibilities to act using egocentric perception, and (ii) an external viewpoint simulation, in which the goalkeeper evaluated the attacker's capabilities and possibilities to act using allocentric perception (Van der Kamp et al., 2008). In this perspective simulating the opponent's action possibilities could be considered as a way for risk evaluation (Van der Kamp et al., 2008), and ensuring or refusing his own first option. This hypothesis needs to be examined in other competitive sports or work settings. From a theoretical perspective, this provides some new insights into the simulation process within the Klein's RPD model.

How does an expert performer cope with uncertainty and urgency?

Previous studies using the RPD model in a sport setting have confirmed that athletes use a diagnostic process when the situation is assessed as non-familiar (Mulligan et al., 2012). Our results suggest that diagnosis consists in deferring decision until additional information is available. For the goalkeeper, dealing with uncertainty consists in standing-up to the first option and search for additional relevant cues, or assuming from available knowledge, conducting to expectancies. Such processes have been also identified in other performance settings (Lipshitz and Strauss, 1997) and are in accordance with findings in ice-hockey capturing eye movement behaviors in a laboratory setting (Martell and Vickers, 2004).

Our results showed the goalkeeper made 4 micro-decisions (i.e., identifying the appropriate standing position, identifying the thrower, identifying the area reached by the thrower, and identifying the end of the shoot direction) to deal with time pressure, which were significantly connected to the distance between the potential thrower and the goalkeeper ($\chi^2(3) = 26.53$, $p = 0.00$). The concept of "micro-decisions" has also been highlighted by Mouchet (2009) in rugby. From a systemic approach, he showed rugby players could make three micro-decisions during 10 m running toward the end zone: going through a free space when catching the ball, continuing to move forward, refusing to pass the ball and going on until being blocked. He argued micro-decisions emerged from the coupling of contextual cues the player took into account and his own actions. In that sense, our results put in light how experts cope with uncertainty and urgency. First, they use very few patterns or options that have been reinforced during previous experiences (Kermarrec and Bossard, 2014); second, these options could be successive micro-decisions: this result highlights the importance of the temporal aspect of the course of action (Mouchet, 2009).

Furthermore, researchers have recently argued that relational information is critical for decision-making in a team sport setting. For example, using a lab-context stimulus-recognition paradigm, North et al. (2009), demonstrated that skilled soccer players recognized stimuli by picking up relational information. Our results suggest that distances between players could serve as discriminant information for decision-making contents in team sport games (Travassos et al., 2012), and that content of decision emerges from those spatiotemporal patterns (Kermarrec and Bossard, 2014; Klein, 1998).

Limitations

A common charge against case study research is that its findings are not generalizable. Advocates of case studies respond to this by arguing that a case study gives access to the inner lives of people, to the emergent properties of social interaction, and/or to the underlying mechanisms which generate human performance (Gomm et al., 2000). Our results are mainly issued from a video-cued recall interview and a qualitative analysis method. This method aims at putting the participant back in the context of his practice so that he can comment on his cognitive, emotional and physical lived-experiences (Macquet, 2009), and explain how previous experiences could organize his perception of situations. Nevertheless the RPD model led us to analyze the player's experience through a "cognitive package", but without any consideration for emotion. This limitation has been taken in account in few studies within the NDM approach because emotions could play a significant role in intuitive decision-making (Lipshitz and Shulimovitz, 2007).

Our study completed the first-person approach with the third-person approach. According to Poizat et al. (2012), and to Hauw (2016), the first-person approach is suitable for retracing the dynamics of athletes' inner experience, whereas the third-person approach could help the researcher highlight behaviours or constraints that could not spontaneously be described by players. Finally, combining qualitative and quantitative analysis, our results provide insights into the relationships between decision-making contents and spatiotemporal constraints (i.e., relative distances from potential throwers). In contrary, the recognition mechanisms the goalkeeper used were not related to distances from the potential thrower. To get a better understanding of how contextual features may influence the goalkeeper's decision-making process, we therefore encourage new research to put in relation the three levels of the RPD model with different types of 1 versus 1 (e.g., penalty, end of counterattack, 9 or 6 m throw, central or lateral throw). Furthermore, we also suggest that other third-person data like the velocity of the ball carrier or the defensive density (i.e., number of defensive players concerned by an offensive trial to get through the defensive wall to throw closer to the goalkeeper) could also influence the goalkeeper's decisions.

Practical Implications

Our results could lead to some practical implications. Recently, behavioral analysis of seven handball goalkeepers in a lab-context demonstrated that they had to employ an anticipatory strategy when facing long distance throws (Gutierrez-Davila et al., 2011). In the present study, the distinctive micro-decisions we found provide support for re-thinking goalkeepers training in handball, or even in other team sports such as soccer and hockey.

We encourage coaches to train goalkeepers to anticipate and make micro-decisions according to the proximity to the critical action in which the goalkeeper needs to stop the ball, instead of focusing on the very last action. In that way, coaches could implement training programs in ecological conditions that could develop recognition ability and lead goalkeepers to "identify the thrower", "identify the area reachable by the thrower", "identify the appropriate standing position" and "identify the end of the shoot direction". As suggested by North et al. (2017), video-based training can be conducted in that sense in experimental settings to develop perceptive and predictive athletes' abilities. Such an initiative has already been implemented with young soccer goalkeepers with video occlusions (Murgia et al., 2014). Complementary simulating the opponent's point of view and attackers' possibilities should help them enhance their allocentric perception (Van der Kamp et al., 2008) so that they could force opponents to act in a wanted way and defeat them.

Furthermore, we suggest to implement challenge (e.g., setting scores to reduce) and noise (e.g., hearing an audio recording of a match) for

example to decision-making training situations. Such contextual features could constrain goalkeepers to train in stressful conditions that are typical of a match context.

Conclusions

Considering the 83 short accounts of decision-making situations, we conclude that each of them consists of a step or stage channeling to a final decision and to an action to stop the shot. In that sense, we call them "micro-decisions". We consider them as a part of a broader decision-making process, and we more specifically argue they are intuitive micro-decisions that lead the goalkeeper to implement a physical response to the situation he faces (i.e., to adjust his standing position, to start a stop technical movement).

Acknowledgments

We would like to thank the head coach and the participant for the interest they both showed toward this research work, and for their willingness and commitment.

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