Applying the Recognition-Primed Decision Model to Differentiate Players' Role in Volleyball

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Abstract

The Recognition-primed decision model (RPDM) explains how experts make decisions when facing situations related to their area of expertise. Key decision makers among experts in a given field can sometimes be identified based on their roles and responsibilities. The aim of this study is to analyze, using the RPDM, how the anticipation process of experts with decisional responsibilities, namely setters in volleyball, differs from that of other experts and non-experts when facing context-specific situations. Twenty-five setters, 36 other players, and 19 controls watched 50 volleyball video sequences: 10 services, 10 receptions, 10 sets, 10 attacks, and 10 blocks. Sequences stopped 120 ms before ball contact, and participants had to explain their anticipation process by answering four questions verbally: "What would you do facing this situation?", "What were you looking at?", "What were you thinking of?", and "What led you to this decision?". Answers were transcribed verbatim. Scores were computed, where points were awarded depending on verbalization number and relevance to the model. Mixed factorial ANOVAs revealed that setters scored higher than other players on three types of ball contacts and higher than controls on all five. Other players had higher scores than controls on all contact types except receptions. In addition, results indicate that players' orientation and position are relevant visual cues. Results support the validity of the RPDM to explain how volleyball players with different levels of decision making responsibilities differ. Discussion suggests the use of RPDM as a tool to identify key decision makers.

Keywords

Typicality recognition, decision making, anticipation, volleyball, positions, setters

Introduction

In team sports, responsibilities and roles vary greatly according to the positions occupied on the playing field (Palao et al., 2014). Anecdotal and sparse empirical evidence suggests that occupying a specific positions in various sports can come with an increased decision-making responsibility, which may be less found in other positions. Examples of such positions include quarterbacks in American football (Hochstedler, 2016), point guards in basketball (Rose, 2004), skips in curling (Saskatoon Curling Club, 2019), catchers in baseball (Perconte, 2015), and setters in volleyball (Fortin-Guichard et al., 2020; Roche, 2011). The latter are designated *playmakers*, whose decision-making responsibilities involve to constantly have to choose which hitter they should pass the ball to in order to maximize the chances of scoring (Palao et al., 2014). This decisional responsibility even leads them to train from a more cognitive perspective than their teammates (Roche, 2011). For example, this training may include watching video sequences or discussing privately with their coaches to learn the strengths and weaknesses of the opposing teams' defense in order to optimize their ball distribution (Patsiaouras et al., 2011). A recent study by Fortin-Guichard and colleagues (2020) shows that, when watching volleyball video sequences, setters and other players differ with respect to their eye-movements, but not their anticipation efficacy. This suggests that the decision-making responsibility inherent to the position of setters may influence decision making and anticipation processes, but not necessarily the resulting decision. A widespread measure of the decision-making process (and anticipation) in sports science concerns verbal reports (Williams & Ericsson, 2005). Do setters perhaps differ from other volleyball players in the way they explain their anticipation process?

Anticipation in Sports

Anticipation in sports has been studied using various approaches. These include anticipation efficacy when facing temporally occluded context-specific video sequences, or by asking athletes to verbally explain what they were thinking about and what they wanted to do at a specific moment of their performance (Farrow & Abernethy, 2002; Macquet, 2009). Both approaches have their strengths and weaknesses. On the one hand, temporal occlusion allows for the use of a systematic experimental protocol, which permits one to isolate the factors of interests. For example, it has been used to show that expertise and task representativeness modulate anticipation efficacy in sports (Mann et al., 2007). However, it has also been extensively questioned with respect to its transferability to the playing field (van der Kamp et al., 2008). On the other hand, verbal reports provide a deeper understanding of the process underpinning athletes' decision making (Williams & Ericsson, 2005), but also involve potential weaknesses, such as memory bias and social desirability. They could even alter the anticipation process (van der Kamp et al., 2008). In the last decade, researchers in sport psychology have tried to combine temporal occlusion and verbal reports by using mixed method designs aimed at counterbalancing their respective weaknesses. Research combining both approaches have consistently shown an expertise advantage in terms of anticipation efficacy and depth of information processing (Martins et al., 2014; McRobert et al., 2011). However, to date, these combined studies are subject to an additional conceptual weakness, as they do not take into account that most sport situations correspond to ill-structured problems that take place within a dynamic and time-pressured environment (Bar-Eli et al., 2011).

Interestingly, alongside research that combines temporal occlusion and verbal reports, another approach aimed specifically at addressing decision making under naturalistic conditions (e.g., with time pressure) has been adapted from other domains to sport psychology. It is conveniently named the naturalistic decision making approach (e.g., Bossard et al., 2010; Kermarrec & Bossard, 2014; Le Menn et al., 2019; Macquet, 2009; Mulligan et al., 2012; Neville et al., 2017). Researchers in this approach are interested in the decision-making process in a real world context (Salas & Klein, 2001; Zsambok & Klein, 1997) and focus mainly on the person's decisions as the primary actor. A decision-making model developed by Klein (1993), namely the Recognition-Primed Decision Model (RPDM), constitutes one of the most frequent aspects of naturalistic decision making that has been adapted to sport psychology. The RPDM aims specifically at explaining how experts make decisions when facing situations in their area of expertise.

The RPDM has been studied in sports mainly by highlighting the decision-making process of an athlete when they must actively choose what to do (e.g., a volleyball hitter who needs to decide whether he will hit diagonally or up the line). Yet, to excel in sports, the anticipation of opponents' actions is a component of decision making of paramount importance (van der Kamp et al., 2008). To the authors' knowledge, the RPDM has only recently been used for the first time to specifically examine the anticipation process of someone else's actions in sports. Indeed, Le Menn and colleagues (2019) conducted a case study with an expert handball goalkeeper to identify how he anticipates his opponents' intentions right before they shoot towards the goal. Their results suggest that the RPDM may also apply to anticipation. Extending this result with a larger sample size of experts could prove useful. Also, it is noteworthy that Le Menn and colleagues questioned the goalkeeper on the day after the match, with the help of video footage of the match, which is the typical research design to study the RPDM in sports (Kermarrec & Bossard, 2014; Macquet, 2009). Therefore, no research has been conducted to date on the efficacy of the RPDM to explain the anticipation process of athletes who are experiencing a situation belonging to their area of expertise for the first time.

What is hereby proposed is a first attempt to combine temporal occlusion and the RPDM in order to reach a broader understanding of the anticipation process of athletes. This would allow for a systematic experimental design, while providing deeper insight into how individuals anticipate situations from their area of expertise. At the same time, using this combination could be an opportunity to differentiate anticipation processes based on decision-making responsibilities on the playing field (i.e., setters in volleyball versus other players). Indeed, the RPDM allows this comparison, as it was originally developed specifically with individuals holding decision-making responsibilities.

The Recognition-Primed Decision Model

The RPDM focuses on how experienced decision makers make decisions in ecological situations within their area of expertise. However, when studying experienced decision makers and developing the RPDM, Klein (1993) did not examine the decision-making mechanisms of all experienced individuals facing an ecological situation; he focused on those with decision-making responsibilities. Indeed, he did not only study firefighters facing a crisis; he was specifically interested in those in command (Klein, 1993; Klein et al., 2010). These individuals must decide, under pressure, how to attack raging fires and how to deploy their team.

The RPDM indicates that, when facing an ecological situation from their area of expertise, experienced decision makers rely directly on their experience to quickly use some or all of the four following by-products to recognize the situation as typical or not and make a decision. The by-products include the following: (a) the plausible goals (prioritizing), (b) the relevant cues (avoiding attentional overloading), (c) their own expectations (to avoid unpleasant surprises), and (d) the typical actions put in place to respond to this situation appropriately. In other words, decision making is grounded in experience-based intuition and recognition rather than in a deliberative comparison of several courses of actions. In this regard, decision makers are sufficiently experienced to rely on patterns gained through experience, even though those patterns have become tacit knowledge that can be difficult to articulate (Kahneman & Klein, 2009; Klein, 2015). Interestingly, inherent ideas to the RPDM including pattern recognition and intuition are similar to classic work on chunking theory from Simon and Chase (1973), even though credit is rarely given to this seminal work in the RPDM literature (Gobet, 2020). Also, for recent reviews on the theoretical distinction between deliberative and intuitive decision making in sports, see Ashford and colleagues (2020) and Petiot and colleagues (2021).

The RPDM has three variations. Facing typical situations where information is rapidly available (Variation 1), experienced decision makers quickly use some or all by-products and make a decision according to what may have worked in the past. In this case, the "if…then" rule applies. Facing situations that do not correspond exactly to a typical situation or that intersect several typical situations (Variation 2), the experienced decision makers allocate more attentional resources to assess the by-products. They quickly identify the differences between the situation at hand and a typical one and build a mental story based on their experience to complete the situation and come to a satisfactory decision. Here, the "if (???) ... then" rule applies. Finally, when a situation is recognized, but several actions can be implemented (Variation 3), different options are considered in one's imagination, without comparing them. These options can be selected, adjusted or rejected. Here, the rule would be "if ... then (???)". Figure 1 illustrates the three variations of the RPDM.

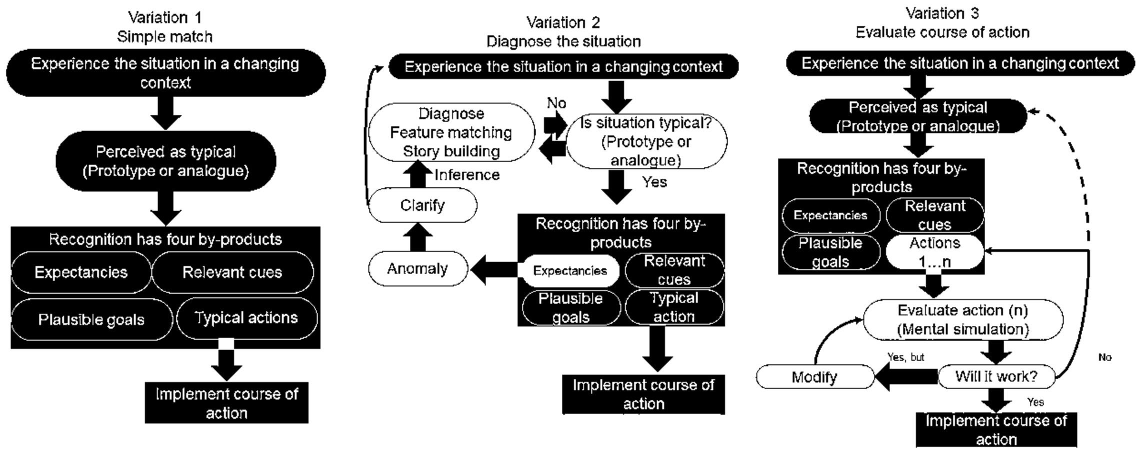

Figure 1. Recognition-prime decision model and its variations. Adapted from Decision Making in Action: Models and Methods (p. 141), by G. A. Klein, J. Orasanu, R. Calderwood, and C. E. Zsambok, 1993. Ablex. Copyright 1993 by Gary Klein.

Much empirical evidence supports the use of the RPDM with experts from various domains, such as medicine (Bond & Cooper, 2006), handball (Johnson & Raab, 2003; Le Menn et al., 2019), ice hockey (Bossard et al., 2010; Mulligan et al., 2012), soccer (Kermarrec & Bossard, 2014), umpiring in Australian football (Neville et al., 2017), karate (Milazzo et al., 2016), and volleyball (Macquet, 2009). In sports, Variation 1 (i.e., simple match) appears to be the most frequent, but it seems to be sport- or task-dependent, as some contexts yield more simulation (i.e., Variation 3; for a review, see Le Menn et al., 2019). For example, asking the athletes to explain their decision process from a third person perspective could elicit more simulation, as they have access to more biomechanical and positional information about their opponents, increasing the opportunities to reaffirm or contradict their first option (Le Menn et al., 2019).

Researchers have raised very few limitations to the RPDM. One limitation was reported by Smith and Dowell (2000) who observed that when a team of experienced decision makers try to manage disasters, the model does not apply, as each expert has a different representation of what the typical situation is. However, at the individual level, their results indicate that they would still use the RPDM. Another limitation concerns the fact that the model does not consider planning (i.e., what experienced decision makers do with their experience before being confronted with a situation that requires decision making). In other words, the model does not take into consideration sport game plans or the action plan that a firefighter might prepare in the truck on the way to the scene of a fire (Macquet & Pellegrin, 2017; McLennan & Omodei, 1996).

The RPDM in Volleyball

Macquet's (2009) study seems to be the only one where the decision-making processes of expert volleyball players were tested using the RPDM. The author collected the verbalizations of seven professional volleyball players in self-confrontation interviews after a match to see if the model applies to the way they make decisions. She asked them about their intention

(“What do you want to do here?”), focus (“What are you looking at?”), thoughts (“What are you thinking of?”), and decision conditions (“What’s leading you to make this decision?”). The results indicate that players recognize most situations as typical, using the four by-products of the RPDM, and that Variation 1 of the model is most often used. The most frequently used by-products were relevant cues and typical actions. She also inductively added a fifth by-product to the model: the consequence of the course of action, which refers to the possible effects of the decision that was made. Even if Macquet’s (2009) study supports the RPDM in volleyball, it contains limitations worth mentioning. First, results can hardly be generalized to all volleyball players because of the small sample size. Second, the study cannot assure that the RPDM applies only to experts, as there was no control group (i.e., novices in volleyball). Third, the analysis is not specific to the anticipation of someone else’s action, but rather to how the players made their own decisions (e.g., why they would hit diagonally rather than down the line). Finally, and most importantly, the decision making of expert volleyball players was studied regardless of their decision-making responsibilities. However, when Klein (1993) proposed the RPDM, he did so based on results obtained from people in command. In light of this, it may be interesting to compare the anticipation process of expert volleyball players according to the decision-making responsibility inherent to the position they occupy. This would illustrate whether athletes with more decision-making responsibilities (i.e., setters) are more likely than other players[1] to follow the RPDM.

The Present Study

The aim of this study was to analyze, with respect to the RPDM, how the anticipation process of experts with decisional responsibilities, namely setters in volleyball, differs from that of other experts and non-experts when facing context-specific situations. Because of their decision-making responsibilities and cognition-oriented training, it was expected that, when anticipating, setters would verbalize more by-products from the RPDM than other players and controls. It was also expected that other players would verbalize more by-products from the RPDM than controls. No hypothesis was formulated regarding the variations of the RPDM that was used as this is the first study comparing experts based on their position. In order to help coaches train young athletes and to give a practical reach to the present study, examples of verbalizations based on the RPDM, as well as the most frequently reported cues and typical actions (rules), were also reported.

To examine participants’ anticipation process, they observed volleyball video sequences that stopped right before ball contact. All types of ball contacts were included (i.e., services, receptions, sets, attacks, blocks), because Le Menn and colleagues (2019) suggested that research should verify whether game phases (in their case, attack vs. defense in handball) influence the recognition process. Participants were invited to explain their anticipation process by answering four questions aimed at eliciting verbalizations in line with the RPDM: “What would you do facing this situation?”, “What were you looking at?”, “What were you thinking of?”, and “What led you to this decision?”. Participants’ verbalizations were transformed in computational scores of resemblance with the RPDM and scores were compared between groups. The suggested approach was innovative in two ways in the field of sports, as it was the first attempt at combining temporal occlusion and the RPDM, and it was the first use of a quantitative measure of the verbalizations related to the RPDM.

Method

Participants

The study sample (N = 80) is composed of three groups: expert setters (n = 25), expert volleyball players from other positions (n = 36), and controls (n = 19). Table 1 describes the three groups in terms of age, sex distribution, number of years/hours of experience in volleyball, and the number of other practiced sports in their lifetime. To be included in the study, participants from both expert groups had to (a) play volleyball in a division 1 or 2 team in University or cégep (a school level between high school and University specific to the province of Québec) and (b) have played at least 4000 hours of volleyball, while participating in at least eight other sports activities (organized or not) in their life (Baker et al., 2003)[2]. As for controls, they had to have accumulated less than 1000 hours of volleyball in their life. All participants had to be 18 years of age or older, have a normal or corrected-to-normal vision using contact lenses, report no history of neurological/psychiatric disorder, and take no medication such as antidepressants, anxiolytics, or neuroleptics.

Table 1. Sociodemographic Characteristics of Setters, Other Players, and Controls

	Groups		
Variables	Setters (*n* = 25)	Other experts (*n* = 36)	Controls (*n* = 19)
% women	40.00[a]	47.22[a]	52.63[a]
Mean age (SD)	19.48[a] (1.42)	19.75[a] (2.00)	23.74[b] (2.35)
Mean number of years playing volleyball (SD)	7.68[a] (1.99)	7.58[a] (2.64)	0.00[b] (0.00)
Mean number of hours of volleyball in lifetime (SD)	4141.32[a] (1419.60)	4648.00[a] (2044.99)	141.05[b] (157.24)
Mean number of other sports practiced in lifetime (SD)	9.04[a] (1.57)	8.81[a] (1.31)	10.95[a] (3.12)

Note. Different letters in superscript indicate a significant difference after Bonferroni correction ($p < .05$) as compared to other groups, whereas same letter indicates no difference.

Recruitment

Two recruitment methods were used to complete both expert groups. First, sports directors from every cégeps and from Université Laval, in the Quebec City region, were contacted by telephone to present the study and schedule an appointment. A written agreement was concluded with them to obtain the contact information of their volleyball head coaches. Coaches were contacted to obtain permission so the researchers could come and present the study to players during a typical practice session. During this practice, athletes were informed of the study and its implications (i.e., one experimental session of about 45 minutes), and their voluntary participation was solicited. A sheet was provided to each athlete where they could indicate their interest and contact information. Those interested were contacted by telephone to determine their eligibility. Second, the first author solicited the participation of volleyball players during a nationwide tournament. Eligibility of those interested was verified on the spot, and those eligible took part in the experimental session immediately. As for controls, a recruiting email was sent to students at Université Laval using automatic mailing lists. Those interested replied to the email with their telephone number. They were called to verify their eligibility. The ethics committee of Université Laval approved this study (approbation number: 2017-001 A-1 R-1/05-09-2018).

Material

Whether participants came to the lab or participated during the tournament, the experimental session took place in a soundproof room free from distractions, on an Intel Core i-7 computer running the Windows 8 system with a 22-inch computer screen. The participants' verbalizations were recorded using a LG digital recorder placed next to the computer screen. The *Tobii Pro Lab* software was used to program the experiment and present the video sequences to the participants. The *QDA Miner 5.0.21* software was used to codify the verbatim transcripts. A sheet with the questions to be answered verbally was available to all participants throughout the experiment as a reminder.

Video Sequences

Two types of video sequences were filmed, using a Nikon 30 Hz camera, and presented to the participants. All sequences were edited using the *Shotcut* software so that each sequence stops 120 ms before every ball contact (Schorer et al., 2013).

First, video sequences of soccer penalty shots from the goalkeeper's perspective were filmed, which served as training for the general functioning of the experiment. To film the video sequences, a camera operator was hired. A soccer field, a soccer goal and a soccer ball were used. A senior AAA soccer player with 21 years of experience as a player and 5 years as a coach shot the penalty shots 11 m away from the camera, which was placed on the center of the goal line. Out of the 54 penalty shots filmed, the player chose the 10 most representative ones.

Second, for the experimental phase, the video sequences illustrated volleyball sequences from the point of view of a back-line player in the center of the field. The camera was elevated 2 m above the back line of the court. A standard volleyball court (18 m × 9 m), a volleyball net (height 2.43 m) and a standard volleyball ball (65 to 67 cm in circumference, 294 to 318 millibars of air pressure) were used. A camera operator was also hired to shoot the footage. Eleven male former cégep and university players (retired for a maximum of two years) were invited to be featured in the video sequences. Three hundred and ninety-seven ball contacts were judged usable by the first author (having 11 years of experience as a volleyball player and 5 years as a coach). This number included 47 services, 73 receptions, 125 sets, 112 attacks, and 40 blocks. The discrepancy between the numbers of usable ball contacts can be explained by the fact that more than one set and attack can be filmed from a same rally. In addition, blocks are typically rarer than other ball contacts.

The first author kept the 20 ball contacts of each type (total of 100) judged most representative according to (a) the clarity of the technical gesture and (b) the equivalent distribution of the ball between the sequences (e.g., seven sets to the left, six sets in the center, and seven sets to the right were selected at this stage). These 100 sequences were shown to two coaches with over 30 years of experience each in volleyball. They had to evaluate the representativeness of the sequences on a Likert-type scale ranging from 0 (*not representative*) to 7 (*perfectly representative*). The 10 sequences of each type (total of 50) with the highest average scores were kept for the experimentation (for a similar selection method, see Maarseveen et al., 2015; Schorer et al., 2013). Before the experiment, sequences were randomized, but all participants viewed the sequences in the same order, so that each participant had an equal chance at detecting patterns in the opponents' game. Note that the 50 sequences were presented for the purpose of a broader study evaluating participants' eye movements and anticipation efficacy (Fortin-Guichard et al., 2020). For the purpose of the present study, verbalizations were required for 25 randomly selected sequences from the initial 50 (five per type of sequence). The 25 sequences were the same for all participants.

Measures

Eligibility Questionnaire

This questionnaire consists of 11 questions (four with short answers and seven with dichotomous responses) that determine the eligibility to participate in the study (see criteria above). For questions requiring further thinking (e.g., number of hours of volleyball during lifetime), the interviewer verbally helped the athletes with the calculation.

Sociodemographic Questionnaire

This self-administered questionnaire consists of seven questions (one dichotomous, three short-answer, and four multi-response) that collect general information such as sex, age, height (meters), and weight (kilograms).

Similitude with the RPDM Model

This measure was based on that of Macquet (2009), as it was the only available study on the RPDM in volleyball, and in which verbalizations in line with the model were successfully elicited. In Macquet's study, participants had to answer four questions verbally about themselves from a prior match: (a) "What do you want to do here?", (b) "What are you looking at?", (c) "What are you thinking of?", and (d) "What's leading you to make this decision?". For the present study, the questions were adapted as the participants were not facing themselves from prior matches, but rather unknown opponents: (a) "What would you do facing this situation?", (b) "What were you looking at?", (c) "What were you thinking of?", and (d) "What led you to this decision?".

Participants' answers were codified based on the five by-products of the RPDM: goals, cues, expectancies, typical actions, and consequences. Unlike the study of Macquet (2009), a computational score was attributed to each participant for each type of ball contact. One point was given every time a by-product was mentioned, for a maximum of five points per sequence (i.e., once a by-product was mentioned, even if another statement falling within the same by-product was verbalized, no point was attributed to the second statement). Goals represented a statement about what they would do to anticipate the opponent's actions. Cues represented statements about visual cues used to make the decision. Expectancies encompassed three subcategories: (a) expectancies *per se*, (b) opponents' tendencies, and (c) teammates' tendencies. Expectancies *per se* constituted statements about what participants anticipated the opponent would do and about when an intention is given to the opponent (e.g., "he wants to attack diagonally"). Opponents' and teammates' tendencies referred to specific knowledge about a player's ability, expertise or role. Typical actions represented either rules or preceding events. Rules referred to what should be followed in a typical game when an association is made between a condition and an action. Preceding events referred to a clear statement about a similar previous situation within the experiment. Finally, the consequences referred to statements about what could happen if an action was implemented (either by themselves as an anticipator or by the player doing the action on screen). A perfect score for a given type of ball contact is 25, since each participant had to observe five sequences, and there are five by-products.

However, after the initial codification was completed, a more continuous score was also calculated. Indeed, participants that verbalized only one irrelevant cue had one point on the initial score for "cues", which was the same as a participant that verbalized four relevant cues. Therefore, the first and second authors (the latter having eight years of experience as a player and three years as a coach) independently identified the most relevant cues for each of the 25 video sequences. Then, all cues reported by the participants were collated and between three and six cues were kept, depending on the drop point in terms of report frequency. The number of relevant cues was voluntarily kept to frequently mentioned and relevant cues to enhance the generalization of the results. Most frequently reported cues were triangulated with the authors' opinions to determine the cues that would be awarded with points. For example, for the first attack sequence, four cues were kept: 56 participants reported "Orientation", 41 "Teammates' actions", 35 "Position", and 34 "Shoulder". In addition, both authors identified these cues as relevant. The next most reported cue was "Ball trajectory" at 24, and neither author identified it as relevant. In this example, each reported relevant cue was awarded 0.25 point. Table 2 explains the operationalization of each by-product and the calculation of the continuous score.

Table 2. Operationalization of Each By-product of the Recognition-Primed Decision Model for the Continuous Score

By-product of the RPDM	Possible labels	Scoring
Goals	Decisions made	One point assigned as soon as a decision is verbalized (no additional point for additional decisions)
Relevant cues (example from first attack sequence)	Orientation Teammates' actions Position Shoulder	0.25 point assigned for each verbalized cue
Expectancies	Expectations Opponent's tendencies Teammate's tendencies	One point assigned as soon as an opponent's or a teammate's tendency is verbalized. If no tendency is verbalized, one point for a realistic expectation where an intention is given to the player. 0.66 point for an unrealistic expectation, but an intention is given to the player or if the expectation is realistic, but no intention is given to the player. 0.33 point for an unrealistic expectation where no intention is given to the player.
Typical actions	Rules Preceding event	One point assigned as soon as a preceding event is verbalized. If no previous event is verbalized, one point for a rule specific to volleyball and linked with the decision. 0.75 point for a rule specific to volleyball, but not linked with the decision made. 0.5 point for a rule on the general functioning of volleyball. 0.25 for a false rule or a rule not linked with volleyball.
Consequences	Consequences	One point assigned for a realistic consequence and 0.5 point for an improbable consequence.

To facilitate comprehension, both the initial and the continuous scores were transformed into a percentage of agreement with the RPDM for each type of sequence. Therefore, if a participant correctly verbalized the five by-products for each of the five attack sequences, he or she would have obtained a score of 25 for attacks, which would translate into a score of 100%.

Variations of the RPDM Used

Every decision was given the label 1, 2 or 3, depending on the variation of the RPDM used (Klein, 1993). To identify the appropriate variation, language features were used (Le Menn et al., 2009). Features included phonological features (e.g., pauses), specialized verbs (e.g., actions verbs versus mental process verbs), and lexical classes (e.g., urgency, uncertainty). Verbalizations with only one course of action without hesitation (i.e., information was rapidly available) were labeled 1. Those showing hesitations or explicitly mentioning that more information would be required to decide were labeled 2. Finally, verbalizations with more than one possible course of action were labeled 3.

Procedure

Eligible and interested participants took part in the study individually. Upon arrival, their written informed consent was obtained, and they completed the sociodemographic questionnaire. They then sat about 60 cm away from the computer screen. The first author explained that they would watch 60 video sequences (10 soccer sequences for training purposes, then 50 volleyball, all preceded by a slide announcing what type of ball contact is coming). The sequences would stop 120 ms before contact of the player with the ball. For all the soccer sequences (training) and for half of the volleyball sequences (i.e., five per type of ball contact), they had to respond verbally to the four questions. They had to respond as if they were the player most solicited to react when the sequences unfreeze (e.g., the defender in an attack sequence or a middle blocker in a set sequence). During the training period with soccer video sequences, the first author stayed with the participants and gave feedback on the appropriateness and quantity of the verbalizations. Soccer was chosen to avoid contamination from the training to the experimental phase. The feedback provided on the verbalization invited participants to mention the course of action they would implement (first question), what information from the screen they used (second question; bottom-up information treatment), what information from themselves they used (third question; top-down information treatment), and what information (bottom-up or top-down) was the most important to them in making their decision (fourth question). The first author then started the digital recorder, left the room, and participants watched the volleyball video sequences and completed the task with the help of the reminder sheet. Upon completion, participants received a CAD $10 monetary compensation to cover travel expenses.

Once all participants completed the experiment, two research assistants transcribed their responses verbatim (a total of 491 pages; 175,338 words). The first author listened to 10 % of the recordings (randomly selected) to ensure that the transcripts were valid, and that no changes were necessary. Then, the first and second author codified (i.e., applied a label for the five by-products where applicable and a label of the variation of the RPDM used on each decision) two randomly selected transcripts, compared their codification and discussed disagreements. This process was repeated with four, six, and eight transcripts until a Scott’s Pi above 70 % was reached (75.8 % after eight transcripts). Then, they both codified 100 % of the data. An agreement of 93.3 % (Scott’s Pi) was obtained. Remaining disagreements were discussed between the first and second author and resolved. After codification completion, similitude scores with the RPDM were calculated for each participant (see Measures section).

Research Design and Data Analyses

This study corresponds to an *ex post facto* quasi-experimental design with a mixed-methods conversion of the data. Conversion mixed-methods are used when data from one type of design are transformed into another type (Guest et al., 2012). Example includes quantification of qualitative data (Chrétien et al., 2018). The independent variables correspond to the group (setters, other players, and controls) and the type of ball contact (service, reception, set, attack, and block). The dependent variables correspond to both similitude scores with the RPDM and the variation of the RPDM used.

All analyses were conducted on the *IBM SPSS 24* software (IBM Corp., Armonk, NY). Percentages, means, and standard deviations are used to describe the sample. One-way ANOVAs (with Bonferroni post-hoc tests) and independence Pearson’s Chi-square were run on the descriptive statistics to verify group homogeneity (Table 1). Because groups differed in terms of age, correlation analyses were run between participants’ age and each dependent variable. No significant correlation were found. Therefore, age was not included as a covariate in any analysis. Transcript segments are used to illustrate the content of participants’ decision-making processes.

Mixed factorial ANOVAs (3 [groups; between-subject] × 5 [type of ball contact;

within-subject]) were conducted on both similitude scores. Post-hoc comparison tests using a Bonferroni correction were run. Five (one per type of ball contact) Generalized Estimated Equations (GEE) analyses were conducted on the variation of the RPDM used with the group as a between-subject factor. GEE were chosen to take into account dependency between the observations of each subject and to allow flexibility in the choice of the variance-covariance matrix as well as the distribution of the data. A multinomial distribution, a cumulative logit link function, and an exchangeable matrix were selected. For all analyses, the alpha threshold was fixed at .05.

Results

Examples of Verbalizations and Scoring Breakdown

All following verbalizations concern the fourth service sequence. The relevant cues for the calculation of the continuous scores were "Orientation", "Shoulder", "Opponents' actions", and "Ball trajectory", each worth 0.25 point. Note that this specific anecdotal comparison was chosen by the first and second authors (i.e., codifiers) because this video sequence elicited much verbalization by many participants and highlighted the between-group contrast in richness and accuracy of reports. The point allocation is described in parentheses and was not part of the transcripts (free translation from French).

In the following verbalizations, it is possible to extract a continuous score of 4/5 (note that in this case, the initial score was also 4/5), with Variation 3 of the RPDM. On the fourth service sequence, a setter reported:

> I first look at his approach, which is quite neutral (0.25 point for the relevant cue "Opponents' actions"). Since it is not a spike serve, we can predict a little less where it will go, because with float serves, it is easy enough to change the direction right at the end: with a slight change in the orientation of the hand, we are able to control where it will go (1 point for a rule specifically related to volleyball and linked with the decision). Other than that, looking at his shoulder, he has quite a standard approach (0.25 point for the relevant cue "Shoulders"). It looks like he is going to hit center, but it can go completely to the left or right without any problem (1 point for an explicit decision and Variation 3 for exploring other possibilities). He did a jump float and I am pretty sure it will go deep, considering his dynamic approach. He seems to want to put a lot of strength; anyways you must give a lot of power in a float service (1 point for a realistic expectation where an intention is given to the player). So, what I was thinking, that's a setter, and usually setters have good float services, but that's according to me. Setters have good ball control, good hand-ball relation (no point for this rule, because a point was already awarded for this by-product). His toss was very good, had a good height. He was still going up when the ball reached its highest point (0.25 point for the relevant cue "Ball trajectory"). His hips also point to the middle of the field, so I predict it will go to the deep center there (0.25 point for the relevant cue "Orientation").

The following verbalizations from a participant in the other experts group were awarded a 2.75/5 continuous score (and a 3/5 score on the initial score) with Variation 1 of the RPDM:

> What I was really looking at was the angle of his hips (0.25 point for the relevant cue "Orientation"). We see that his steps were made in a straight line, parallel to the court (0.25 point for the relevant cue "Opponents' actions"). We also see his shoulder opening, which is facing us (0.25 point for the relevant cue "Shoulders"). His natural movement would be to hit in a straight line (1 point for a rule specifically related to volleyball and linked with the decision and 1 point for an explicit decision with Variation 1 of the RPDM).

Finally, the following verbalizations from a control participant were awarded a 1.75/5 continuous score (and a 3/5 initial score) with Variation 1 of the RPDM:

> I feel the ball will come toward the bald person in the middle of the screen (1 point for an explicit decision and Variation 1 of the RPDM). I look at the ball and the hand of the server (0.25 for the relevant cue "Ball trajectory") and I think he will touch the ball right in its middle, which could lead the ball to pass very close to the net (0.5 point for an improbable consequence).

For the purpose of giving an applied scope to the results, Table 3 lists the most frequently reported cues, as well as examples of frequently reported rules by both expert groups for each type of ball contact. Examples of consequences, expectancies, and goals are not provided because consequences were too seldom reported, expectancies varied too much from one participant to another, and decisions occurred on every sequence and were too context specific.

Percentage of Similitude with the RPDM (Initial Score)

Figure 2 illustrates the mean percentage of similitude with the RPDM on the initial score and standard error as a function of groups and ball contact types. Conditions for the utilization of the mixed factorial ANOVA were met, as Box's test for equality of covariance matrix and Mauchly's test of sphericity were both non-significant (p = .986 and p = .592 respectively). The Group × Ball contact type interaction was not significant for the percentage of similitude with the RPDM on the initial score, $F(8, 308) = 1.527$, $p = .147$, $\eta^2 = 0.04$. The main effect of Group was significant, $F(2, 77) = 4.803$, $p = .011$, $\eta^2 = 0.11$, as well as that of ball contact type, $F(4, 308) = 5.805$, $p < .001$, $\eta^2 = 0.07$. Post-hoc Group comparisons were run separately for each type of ball contact.

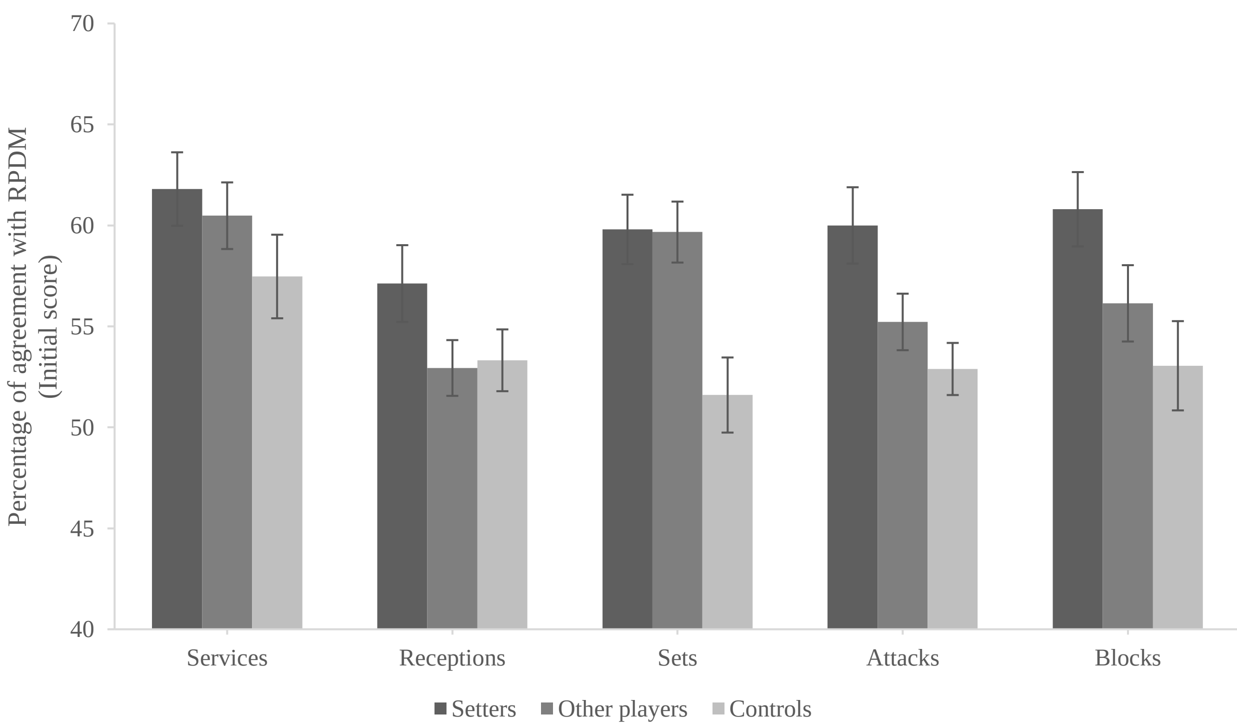

Figure 2. Mean percentages of agreement with the *Recognition-Primed Decision Model* (initial score) as a function of groups and sequence types. Error bars represent the standard error of the means.

Table 3. Most Frequently Reported Cues as a Function of Type of Ball Contact, with Examples of Frequently Reported Rules

By-product of the RPDM	Sequence type				
	Service	Reception	Set	Attack	Block
Cues					
Orientation	5	5	3	5	5
Shoulders	5	0	0	4	0
Position	0	5	5	5	5
Teammates' actions	0	0	0	4	4
Opponents' actions	5	0	5	1	1
Ball's trajectory	5	1	0	2	3
Laterality	0	0	0	1	0
Hands	0	0	4	0	1
Jump height	0	0	0	0	2
Posture	0	5	2	0	0
Back	0	0	2	0	0
Lower body	0	4	0	0	0
Arms	0	4	0	0	0
Typical actions					
Rules	"If you toss the ball above your shoulder, it will be easier to hit wherever you want." "Shoulders' orientation gives crucial information on the direction of the ball."	"Proper orientation of the lower body makes it easier to direct the ball to the setter." "You should place your shoulder square behind the ball and attack it rather than letting it hit you."	"When the setter's back is arched, it is a sign that he will pass the ball behind." "When a setter has to squat low, he is less comfortable setting to the middle player."	"When there are two blockers on the diagonal, you should try to hit the line." "If you persist in hitting the line with a set that is too inside, you increase the chances of being blocked."	"Hitters should take advantage of small blockers." "When you block alone facing a hitter, it is preferable to block towards the inside of the court to cut as much angles as possible."

Note. Numbers associated with the cues describe the number of sequences (out of 5) where each cue was identified as relevant. Other cues emerging from the transcripts, but never identified as relevant, included Torso, Thumbs, Elbows, Size, Head, Hips, and Wrist.

Services

There were no group differences for service sequences.

Receptions

Setters (*M* = 57.12; *S.E.* = 1.70) corresponded more to the RPDM than other players (*M* = 52.94; *S.E.* = 1.42; unilateral *p* = .032). However, setters and other players did not differ from controls (*M* = 53.32; *S.E.* = 1.95; unilateral *p* = .073 and *p* = .439, respectively).

Sets

Setters (*M* = 59.80; *S.E.* = 1.77) did not differ from other players (*M* = 59.67; *S.E.* = 1.48; unilateral *p* = .477). However, setters and other players both corresponded more to the RPDM than controls (*M* = 51.60; *S.E.* = 2.03; unilateral *p* = .002 and *p* = .001, respectively).

Attack*s*

Setters (*M* = 60.00; *S.E.* = 1.67) corresponded more to the RPDM than other players (*M* = 55.22; *S.E.* = 1.39; unilateral *p* = .016) and controls (*M* = 52.90; *S.E.* = 1.92; unilateral *p* = .004). Other players did not differ from controls (unilateral *p* = .164).

Blocks

Setters (*M* = 60.80; *S.E.* = 2.10) corresponded more to the RPDM than other players (*M* = 56.14; *S.E.* = 1.75; unilateral *p* = .046) and controls (*M* = 53.05; *S.E.* = 2.41; unilateral *p* = .009). Other players did not differ from controls (unilateral *p* = .152).

Percentage of Similitude with the RPDM (Continuous Score)

Figure 3 illustrates the mean percentage of similitude with the RPDM on the continuous score and standard error as a function of groups and ball contact types. Conditions for the utilization of the mixed factorial ANOVA were met, as Box's test for equality of covariance matrix and Mauchly's test of sphericity were both non-significant ($p = .103$ and $p = .265$ respectively). The Group × Ball contact type interaction was not significant for the percentage of similitude with the RPDM on the continuous score, $F(8, 308) = 1.564$, $p = .135$, $\eta^2 = 0.04$. The main effect of Group was significant, $F(2, 77) = 15.834$, $p < .001$, $\eta^2 = 0.29$, as well as that of Ball contact type, $F(4, 308) = 4.737$, $p = .001$, $\eta^2 = 0.06$. Post-hoc Group comparisons were run separately for each type of ball contact.

Services

Setters (*M* = 53.86; *S.E.* = 1.99) did not differ from other players (*M* = 50.92; *S.E.* = 1.66; unilateral *p* = .13). However, setters and other players were more similar to the RPDM than controls (*M* = 40.67; *S.E.* = 2.29; both unilateral $p < .001$).

Receptions

Setters (*M* = 48.80; *S.E.* = 1.80) were more similar to the RPDM than other players (*M* = 42.99; *S.E.* = 1.50; unilateral *p* = .008) and controls (*M* = 38.91; *S.E.* = 2.06; unilateral $p < .001$). Other players did not differ significantly from controls (unilateral *p* = .057).

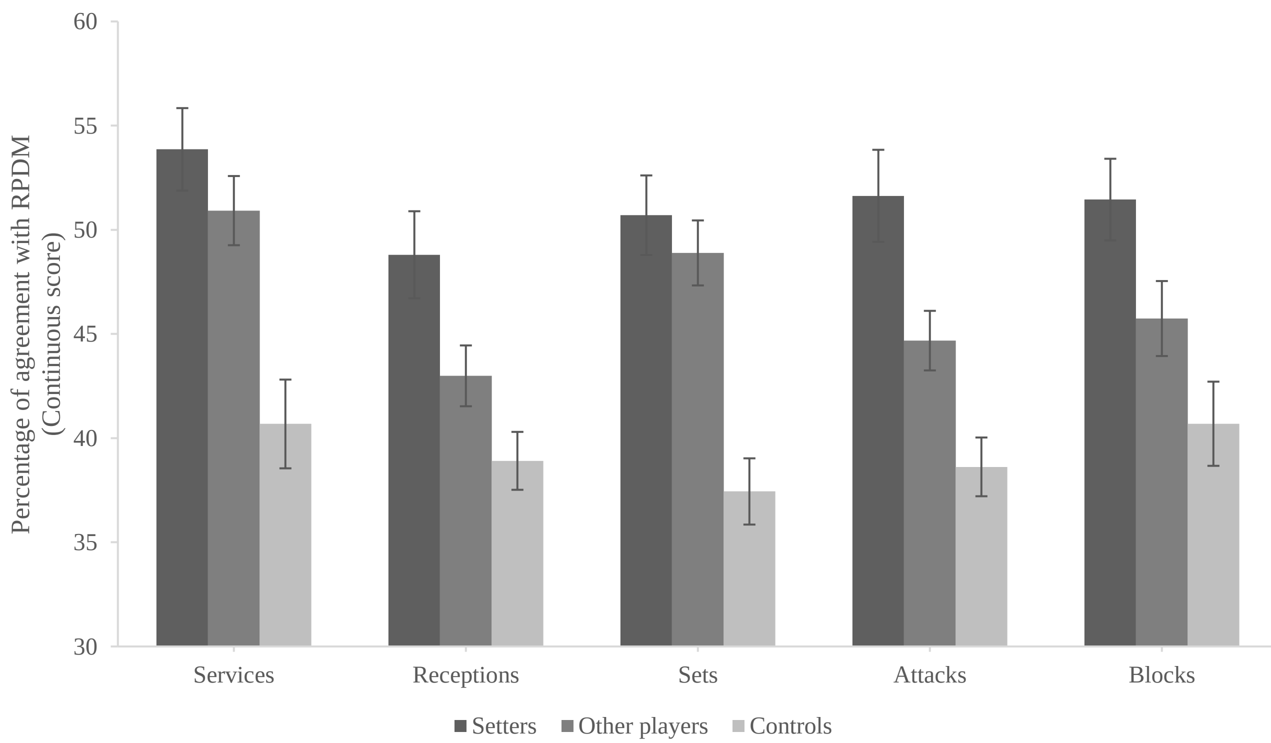

Figure 3. Mean percentages of agreement with the *Recognition-Primed Decision Model* (continuous score) as a function of groups and sequence types. Error bars represent the standard error of the means.

Sets

Setters (*M* = 50.71; *S.E.* = 1.82) did not differ from other players (*M* = 48.87; *S.E.* = 1.52; unilateral $p = .223$). However, setters and other players both corresponded more to the RPDM than controls (*M* = 37.44; *S.E.* = 2.09; both unilateral $p < .001$).

Attacks

Setters (*M* = 51.63; *S.E.* = 1.83) corresponded more to the RPDM than other players (*M* = 44.68; *S.E.* = 1.52; unilateral $p = .003$) and controls (*M* = 38.62; *S.E.* = 2.10; unilateral $p < .001$). Other players also corresponded more to the model than controls (unilateral $p = .011$).

Blocks

Setters (*M* = 51.45; *S.E.* = 2.05) corresponded more to the RPDM than other players (*M* = 45.74; *S.E.* = 1.71; unilateral $p = .018$) and controls (*M* = 40.69; *S.E.* = 2.35; unilateral $p < .001$). Other players also corresponded more to the model than controls (unilateral $p = .043$).

Variation of the RPDM Used

Figure 4 illustrates the proportion of each variation of the RPDM used as a function of the groups and the types of ball contacts. The GEE analysis revealed no Group effect on the variation of the RPDM used in any type of ball contact (Services: $\chi^2_w(2) = 0.763$, $p = .683$; Receptions: $\chi^2_w(2) = 0.965$, $p = .617$; Sets: $\chi^2_w(2) = 0.849$, $p = .654$; Attacks: $\chi^2_w(2) = 3.613$, $p = .164$; Blocks: $\chi^2_w(2) = 3.408$, $p = .182$).

Discussion

The aim of the present study was to analyze, using the RPDM, how the anticipation process of experts who have substantive decision-making responsibilities (i.e., setters in volleyball) differs from that of other experts from the same field and non-experts when facing context-specific situations. More specifically, the RPDM was used to compare the three groups on the similitude of their anticipation processes when facing all types of ball contacts in volleyball. It was expected that setters would conform to the RPDM more than other players and controls, and that other players would conform to this model more than controls. Results lend support to this hypothesis. Indeed, when looking at the continuous score of similitude with the RPDM (which is a more refined measure than the initial score), setters had higher scores than other players on three out of five types of ball contacts (i.e., receptions, attacks, and blocks). They also had higher scores than controls on all five. Other players had higher scores than controls on all types of ball contacts except one (i.e., receptions).

These results reflect those of Macquet (2009), as they also lend support to the RPDM in expert volleyball players, while using a larger sample, and including a control group. Because of the differences found between both expert groups and controls (with an advantage for expert groups), it is reasonable to say that the RPDM indeed constitutes an expert decision-making model that applies to sports, at least in the context of anticipation in volleyball. Results also corroborate those found in other team sports like handball (Johnson & Raab, 2003; Le Menn et al., 2019), ice hockey (Bossard et al., 2010; Mulligan et al., 2012), and soccer (Kermarrec & Bossard, 2014), thus suggesting that experts from a variety of sports use their recognition abilities to make decisions. As stated by Macquet (2009), expert volleyball players gain learning experience from practice and matches, which controls do not have. During training, players learn rules about the game, where to direct their attention, and how to gain knowledge about specific opponents and teammates. This learning process allows them to memorize key information, which facilitates the recognition process depicted in the RPDM by enhancing familiarity (Mulligan et al., 2012). Regarding matches, athletes memorize game situations and their consequences to replicate what worked and avoid what did not, but also to learn what their opponents tend to do in various situations. Memory has been argued as an underlying mechanism involved in numerous perceptual-cognitive abilities in sports, including anticipation (Memmert & Roca, 2019), and could explain in major part the expertise effect found in the present study. All this information, acquired and stored from training and matches, is in relation to by-products of the RPDM, potentially explaining why experts from both groups in the present study verbalized more than controls.

An important nuance to put forth comes from the fact that controls in the present study did not score zero, but rather scored around 35-40 % on all types of ball contacts, making the RPDM not exclusive to expert volleyball players. However, since controls were asked the same questions as experts (e.g., “what were you looking at?”) and these questions were designed to elicit verbalizations in line with the RPDM, their responses could have been oriented that way to some extent. Therefore, it is more probable that the RPDM is at least more specific to experts in volleyball than it is to people in the general population. Another explanation could lie in the fact that the control group was comprised of active people, many of which had experience in team sports. It is plausible that they transferred rules from other sports to volleyball, allowing them to score points. Indeed, skill transferability has been discussed on numerous occasions in sports science (Abbott & Collins, 2004). Finally, it could also be that expert knowledge, especially in sports, is highly intuitive (at least in view of the RPDM), and difficult to fully measure by decomposing it into by-products proposed by the RPDM model (e.g., Gobet & Chassy, 2009), as it is based on tacit knowledge that can be hard to articulate. This might explain why experts only obtained scores of about 50-55 %, while controls were able to score around 35-40 %. For example, a sports journalist (or in this case, an active control), would do relatively well without having any real procedural expertise in volleyball. Still, one novelty of the present study is the fact that the RPDM may not exclusively explain how expert decision makers anticipate when facing situations in their area of expertise; it could, to some extent, explain how all individuals (i.e., the experienced and non-experienced alike) anticipate.

The present study not only supports the RPDM as an expert decision-making model in volleyball, but also suggests that it adapts even better to people with decision-making responsibilities (i.e., setters). Even if players from other positions had the same amount of volleyball experience as setters (i.e., > 4000 hours), they had lower scores on three out of five types of ball contacts. In addition, the two types of sequences where differences were not found (i.e., sets and services) can be explained in terms of role during a typical game. Indeed, the other expert group included middle players, who are responsible for anticipating the opponent setters’ intentions, and also included hitters and liberos, both responsible for receiving opponents’ services. Setters do not need to anticipate opponent setters’ actions or receive services in a typical game, and they still scored as high as other players on these two types of ball contacts. These results empirically support that the RPDM explains even more specifically the anticipation process of individuals with decision-making responsibilities (i.e., setters) than it does for experts in general.

The present study also explored if there were differences between the three groups according to the variation of the RPDM used. No hypothesis was formulated. Results show that groups did not differ with regard to the variation of the RPDM. Indeed, in all types of ball contacts, all participants often chose only one course of action (Variation 1). The next preferred path to a decision corresponded to Variation 3, and Variation 2 was used much less. These results are consistent with those reported in other sport studies where Variation 1 was the most frequently used by experts (Bossard et al., 2010; Macquet, 2009). However, the fact that Variation 3 was somewhat frequent (see Figure 4) raises the following question: under which circumstances do athletes rely almost exclusively on simple matches and only occasionally on mental simulation?

The answer may lie in the third-person perspective adopted in the present study. Indeed, athletes had access to a wider range of information (biomechanical, positional) rather than only describing their own experience from a first-person perspective. This perspective probably gave them an opportunity to counterverify the first option they generated (Le Menn et al., 2019). Also, it is possible that this perspective gave an advantage to setters, as their role invites them to plan in advance and “see the bigger picture” during a match. Two other studies found occasions where Variation 3 was somewhat frequent. They also support the involvement of the third-person perspective, as the first study was about the defensive phase in soccer (i.e., a situation where athletes have an overall view of the unfolding action; Kermarrec & Bossard, 2014) and the second covered the anticipation process of a handball goalkeeper when he was given access to information from both perspectives (Le Menn et al., 2019). In all other sport studies conducted to date, athletes only had access to a first-person perspective, thus possibly explaining the majority of simple matches observed (i.e., Bossard et al., 2010; Macquet, 2009). The higher use of Variation 3 in the present study could also be linked to the fact that participants had unlimited time to answer. Although they were asked to answer as fast as possible, it could be that a more deliberative decision-making process was solicited rather than the intuitive process described in the RPDM (Ashford et al., 2020; Petiot et al., 2021).

In another line of thought, the fact that the various ball contact types did not differ regarding which variation of the RPDM was used also suggests a response to a secondary question raised by Le Menn and colleagues (2019), namely that the recognition and anticipation processes might be independent of the game phase when anticipating opponents’ actions. This could mean that acquiring knowledge and experience in a given sport (or maybe in another field) is a global process, allowing athletes to develop typical mental representations of every game phase of their sport. However, this interpretation is to be viewed cautiously, as controls did not differ from both expert groups in terms of the variation of the RPDM used. This is quite surprising. Variation 1 of the RPDM suggests that typicality recognition is fast. It is improbable that controls had pre-existing prototypical volleyball representations in memory, since they cumulated only around 140 hours (on average) of volleyball during their lifetime, mostly from physical education classes in high school. It is more plausible that controls most often chose only one course of action because they could not imagine more possibilities based on the information presented or their previous knowledge. In this line of thought, it could have been expected that controls would most often anticipate using Variation 2 of the RPDM (i.e., hesitations or more information needed). However, it is also possible that they could not understand if important information was missing from the sequences and could not implement an anticipation process resembling Variation 2. Because of the great discrepancy in the number of volleyball hours, but the similarity found with regard to the variations of the RPDM used, it is possible that the way these variations were measured in the present study lacked sensitivity. Indeed, maybe both expert groups quickly recognized situations as prototypical (i.e., actual Variation 1 of the RPDM), whereas controls only gave one possible course of action because they were only able to do so.

From a practical point of view, the present results invite volleyball coaches to learn about the mechanism underpinning the RPDM in order to orient young players on how they should anticipate during a game. The present results support the idea that this anticipation strategy develops automatically with hours of training. However, coaches could accelerate this process and even improve it in order to make sure athletes are better decision makers when they arrive at higher levels. Coaches can take inspiration from the present study to teach young players the importance of learning the implicit rules of the game or which visual cues are the most relevant depending on the type of ball contact they are facing (Table 3). The present study highlights that the orientation of a player and his position (i.e., geospatial positioning compared with other players) seems to be information of the utmost relevance to anticipate the follow-up action in almost all types of ball contacts. Theoretically, the results invite sport and cognition scientists to use the

RPDM as a tool when it comes to identifying and studying key decision makers, whether it is in sports or in other fields.

Apart from the potential lack of measure sensitivity on the variation of the RPMD used (see above), the present study has other limitations worth mentioning. Indeed, the RPDM tries to predict and explain how experts in a given field make their own decisions in a natural environment. However, in the present study, participants had to explain what they would do when facing controlled situations they had not personally experienced in a game. This could have hindered not only the accuracy of the anticipation, but also the ecological validity of the study. This study is considered a stepping-stone towards studying the RPDM on large samples, eventually allowing to adapt the present design to natural situations. Another limitation concerns the fact that the video sequences portrayed retired senior players in a structured, yet recreational game, whereas expert participants were still active competitive players. Even if participants had to explain their decisions prior to ball contact, senior players do not always follow a “by the book” plan of action. Therefore, it is possible that typical rules and courses of action were not followed on screen, which could have hindered participants’ ability to describe what they would do and why. Of note is that only one participant (a setter) mentioned this potential problem. Finally, the depth of the qualitative analysis of the verbatim could be considered shallow when compared to the rest of the literature regarding the RPDM in sports. However, the study was constructed to facilitate generalization, and, in that sense, an in-depth analysis of self-confrontation interviews eliciting more verbalizations (and therefore allowing deeper analysis) of a large sample was considered impractical.

Strengths of the present study include the sample size and the presence of a control group to empirically support the RPDM as a reliable tool to explain how experts anticipate when facing situations within their field, especially in volleyball. An important strength resides in the codification strategy used and the inter-rater agreements obtained. The first and second authors were able to achieve complete agreement on which code to assign to each text segment (93.3 % Scott’s Pi plus agreement discussion), allowing for high confidence that the quantitative analyses were run on valid material. Finally, the most relevant strength of the present study relates to its novelty, as it is the first one to attempt to adapt the RPDM in a controlled setting and to suggest a quantification of resemblance with the RPDM, at least in sports.

Based on the present study’s results and limitations, future research could try to find a more sensitive measure for the variation of the RPDM used to distinguish experts and controls on their recognition of typicality. For example, Variation 1 could be attributed only when it is clear that the answer seemed obvious for the participant, rather than when only one course of action is mentioned and no hesitation was shown. This could confirm or infirm that the RPDM is exclusive (or at least more specific) to experts. In addition, similar to Macquet’s (2009) study, self-confrontation interviews could be conducted with a sample of volleyball players resembling that of the present study (i.e., large, and including a control group). This could add weight to the validity of the RPDM in volleyball by identifying how these athletes anticipate, but with a more empirically sound design. Finally, researchers could replicate the present study in other team sports. For example, they could compare quarterbacks in American football with other players with the same amount of experience to see if the RPDM holds true.

Results from the present study lend support to the RPDM in volleyball, at least in a controlled environment facing new situations. Indeed, it appears that expert volleyball players tend to anticipate based on the use of the by-products depicted in the model and tend to recognize volleyball situations as typical rather than comparing options. The results go even further by providing support to the idea that the RPDM specifically explains the way players with greater decision-making responsibility (i.e., setters) anticipate in volleyball. Researchers are invited to identify key decision makers in other sports to test the validity of the RPDM across fields.

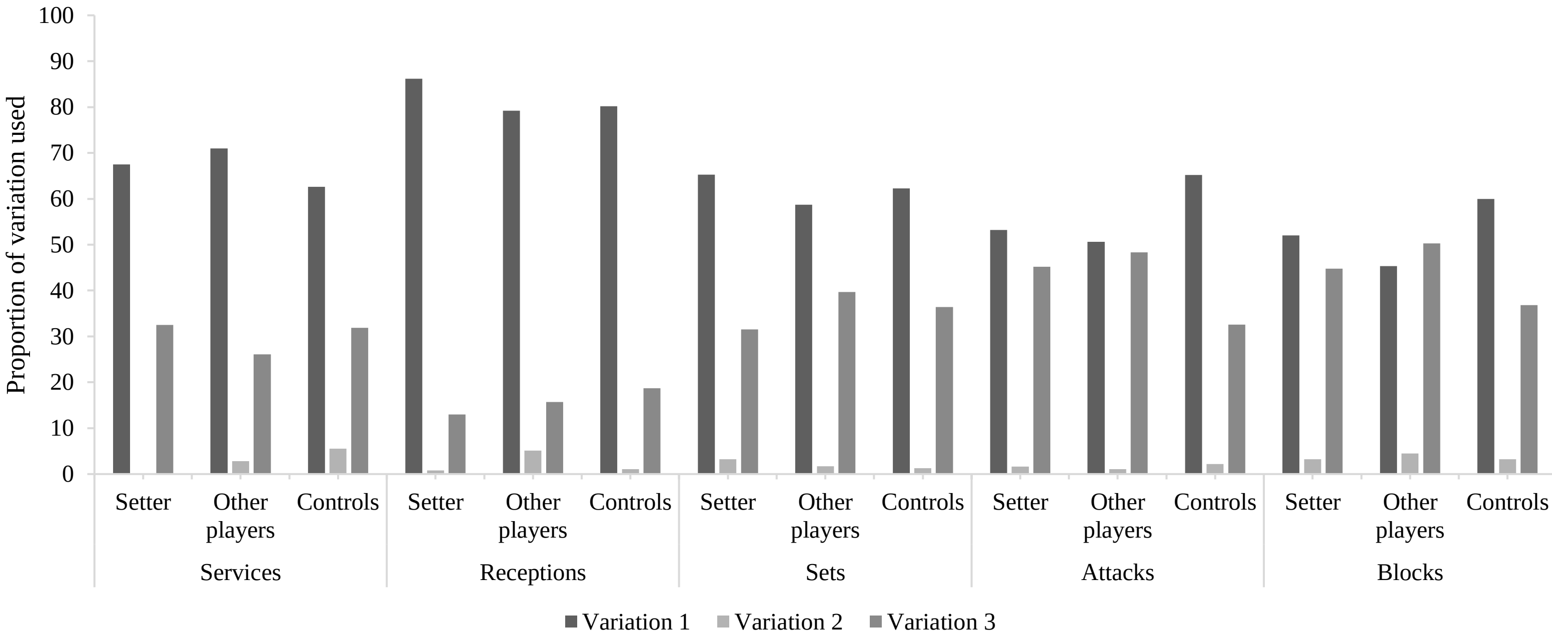

Figure 4. Proportion of each variation of the *Recognition-Primed Decision Model* used, according to groups and sequence types. Proportions within a same position and a same type of ball contact equal 100%

Endnotes

1. Other players include: (a) middle players, whom have a primary role in blocking opposing attacks and a secondary role in executing attacks by their own team (Gualdi-Russo & Zaccagni, 2001); (b) hitters, whom are versatile players specialized in both receptions and defense, but especially in attacking (Palao et al., 2014); and (c) liberos, only solicited for reception and defense, never going to the net (Sheppard et al., 2009).

2. This criterion had to be relaxed as the recruitment went on since some participants, for example, had accumulated about 3000 hours of volleyball while having participated in 12 other activities or conversely, had accumulated about 8000 hours of volleyball, without taking part in at least eight other activities. It seemed that excluding such experienced volleyball players would result in important data loss.

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Authors' Declarations

The authors declare that there are no personal or financial conflicts of interest regarding the research in this article.

The authors declare that they conducted the research reported in this article in accordance with the Ethical Principles of the Journal of Expertise.

The authors declare that they are not able to make the dataset publicly available but are able to provide it upon request.

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