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Situational familiarity and its relation to decision quality in ice-hockey

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Field-based observation, including helmet-mounted cameras, was employed to study pattern-matching aspects of decision making in ice-hockey. We were interested in the role of situational familiarity in decision making and decision quality. Expert and non-expert players were videotaped during competition. In retrospective interviews, prompted by the game videos, players were asked about the role that familiarity (both event and rule-based), played in their decision-process. Decision quality and decision outcome were assessed retrospectively by two expert coaches. Experts described decision-making situations as 'familiar' twice as often as non-experts. Although rule-based decisions were more common, only for decisions based on recognition of the event, were familiar decisions rated as better quality. This pattern-matching aspect of the decision-making process and its relationship to decision quality has implications for theories of decision making in dynamic sports.

Keywords: expert performance; pattern recognition; decision making; sport

The ability to make rapid, effective, and accurate decisions is one of the attributes that sets experts apart from novices. It has been suggested that a key component underlying this decision-making advantage is the ability to recognise familiar features or patterns in the available visual information (Chase & Simon, 1973a, 1973b; de Groot, 1978; Klein, 1998). While it might seem obvious that being familiar with a particular situation would provide an information advantage, the link between situational familiarity and decision-making quality has not previously been examined in dynamic situations *in situ*. In the current study, we examined the role of familiarity in the decision-making process of ice hockey players during competition. The specific aims were to test how frequently expert athletes, in comparison to non-expert athletes, rely on familiarity to make decisions in these environments, and to determine whether this familiarity is related to both decision and outcome quality.

According to traditional memory-based models of expertise (Chase & Simon, 1973a, 1973b; de Groot, 1978) the expert advantage in decision making is explained by larger stores of patterns, or 'chunks' in long-term memory in comparison to the novice performer. Externally perceived patterns are believed to be matched for familiarity with internal, stored patterns, and an associated response is then activated and prepared. These ideas are based on the work of Chase and Simon who showed that experts were much better at remembering meaningful, game-representative chess configurations than novices. Subsequently, Ericsson and Kintsch (1995) introduced their Long-Term Working Memory (LTWM) model to further explain the expert advantage. Accordingly, as a result of many years of structured practice,

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experts are able to circumvent basic information processing limits through the use of domain-specific retrieval structures in LTWM, enabling better efficiency and capacity in working memory (Ericsson & Kintsch, 1995). Importantly, these retrieval structures are not necessarily tied to the ensuing response, but allow for evaluation of various 'best' options (Ericsson, Patel, & Kintsch, 2000).

Later, Gobet and Simon (1996, 1998) proposed the notion of memory templates to explain the influence of semantic knowledge during encoding and retrieval – that is, knowledge about the situation's meaning and context in the pattern-matching process. Support for this premise came from a study of chess experts by Cooke, Atlas, Lane, and Berger (1993) showing that encoding a chess position requires knowledge that goes beyond simply that of perceptual chunks. This knowledge is said to take the form of familiar or prototypical situations or 'events' (Cooke et al., 1993). This idea of typicality or familiarity was further expanded by McPherson and colleagues to include prototypical, rule-based procedures, available to experts when addressing a given decision scenario. These rules take the form of condition-action responses, such that, given condition 'C' perform action 'A' (see French & McPherson, 1999; McPherson, 1999; McPherson, 2000; McPherson & Kernodle, 2003, who have termed these types of rule-based decision processes 'action plan profiles'). Thus, the recognition of a situation as typical or familiar can take the form of either event- or rule (procedural)-based knowledge structures. Finally, there has recently been a model of decision-making based on a fast, pattern matching heuristic, whereby decision quality is presumed to be enhanced if the first decision that comes to mind is chosen (Johnson & Raab, 2003; Raab & Johnson, 2007). This model also carries the assumption that retrieval structures associated with judgements of familiarity are tied to a specific 'optimal' decision. It is this link between familiarity, these characterisations of situational typicality and their influence on decision quality that we examine in the current study.

Laboratory-based studies have generally been the method of choice for examining perceptual-motor decision-making and pattern recognition skill (see Ericsson & Smith, 1991; Ericsson & Williams, 2007 for reviews; Starkes & Ericsson, 2003). Typically, representative tasks that are believed to tap into the domain knowledge of experts have been used, and the experiments often involve recall and recognition measures after controlled exposure to static or dynamic images (e.g. Helsen & Pauwells, 1992; Johnson & Raab, 2003; Raab & Johnson, 2007; Starkes & Deakin, 1984; Williams, Hodges, North, & Barton, 2006). Skill-based differences have been observed in both the speed and accuracy of memory processes and decisions after brief exposure to domain-specific perceptual stimuli. Many of these tasks require that the link between perception and action be uncoupled in order to maintain experimental control – that is, verbal, rather than motor responses are generally employed.

There is evidence, however, showing that preservation of the perception and action coupling observed during play is beneficial for exposing the specific underlying expert advantage. In a study examining coupled and uncoupled responses to tennis serves, Farrow and Abernethy (2003) found superior prediction accuracy from both experts and non-experts in the coupled (motor response, as if returning serve) versus the uncoupled (verbal prediction of ball direction) condition. These findings underscore the importance of maintaining perception-action links in order to validly assess decision making in dynamic environments.

The Naturalistic Decision-Making (NDM) approach provides a complementary methodological framework from which to study expertise and decision-making in more natural, dynamic environments that are characterised by temporal and perceptual constraints, competing goals, and uncertainty (see Salas & Klein, 2001, for reviews; Zsambok & Klein, 1997). What differentiates the NDM approach from laboratory methods is its emphasis on studying expert performance *in situ*, and its use of models and methodologies that preserve natural perception-action couplings while capturing and describing the nature of expert performance in real-world settings. Not unlike the pattern matching models which have primarily emerged from laboratory tasks, the NDM approach is also grounded in the premise that decisions are based on fast, pattern-matching processes which generally result in the rapid generation of one 'sufficient' option. In this way, retrieval of events is linked somewhat automatically to a best or optimal response (Klein, 1989, 1997; see also Johnson & Raab, 2003), rather than the retrieval process being separate from the actual decision or outcome (*cf*., Ericsson & Kintsch, 1995).

Methods from the NDM approach, including field-based observation, video-based stimulated recall and retrospective interview techniques, among others, have been employed to specifically examine the recognition of familiarity/typicality in the decision process *in situ* (Klein, 1989; Macquet, 2009; Omodei, McLennan, & Wearing, 2005). Recently, the NDM approach has been employed to investigate the recognition of familiarity in sport (Macquet, 2009; Macquet & Fleurance, 2007). During competitive play in volleyball, 63 out of 70 decision points were recognised by experts (in retrospective, video-prompted recall) as typical of either a preceding event or rule-based scenario (Macquet, 2009). These distinctions were based on the event- or rule (procedural)-based knowledge structures identified by McPherson and colleagues (e.g. McPherson & Kernodle, 2003). However, no measures of corresponding decision or outcome quality were taken to verify whether the decisions based on familiarity were actually of better quality than those that were not judged to be familiar. Moreover, the video prompts were not from the first-person player perspective but rather from the sidelines. In addition, no comparisons were made across differently skilled athletes.

In the current study, we examine the proposal that familiarity provides a mechanism to explain the expertise effect in dynamic decision-making environments, such as team sports. Ice hockey was chosen as a base from which to examine these decision processes because of its dynamic nature, and the wide variety of unique patterns and game configurations that are encountered by players *in situ* (i.e. during competitive play), presumably making familiarity-based judgements less common.

Unlike repeated scenarios presented in laboratory-based, pattern-recognition studies it would be highly unlikely that a player would be presented with an exact pattern match during a real game situation. As a result, we were interested in players' perceptions of decision scenarios as 'familiar' rather than precisely identical. A 'typical' or 'familiar' scenario would be one in which a player could recall either a previous similar event or a familiar set of rule/procedures that provided an appropriate response to the decision at hand (Macquet, 2009).

We were specifically interested in how these judgements based on either event or rule-based familiarity correlated with skill level, and more importantly, whether decisions based on these types of familiarity were of better quality than those not perceived to be governed by these same recognition processes. We hypothesised that decisions based on familiarity or typicality would be reported more often by expert athletes than non-expert athletes (Klein, 1998; Macquet, 2009). If situational recognition or familiarity is integral to expert decision-making in dynamic, competitive situations, we hypothesised that decisions based on familiarity would be judged to be of better quality than those which were not. This question has not been explored previously, at least in sports, yet it is important in understanding the role familiarity plays in the decision process for skilled performers in such dynamic settings. Moreover, according to strict pattern matching accounts of decision-making, a strong relationship between judgements of familiarity, particularly event-based familiarity, and decision quality would be expected, whereas this same relationship would not necessarily be predicted based on more evaluative models such as the LTWM model of Ericsson and Kintsch (1995).

1. Method

1.1. *Participants*

Twenty-three male expert hockey players ranging in age from 15 to 17 years ($M = 16.13$; $SD = .72$ yr), and non-expert (intermediate house league) players ($n = 14$) of a similar age range ($M = 15.84$; $SD = .54$ yr) were studied. Informed consent was obtained in accordance with institutional ethical guidelines. The experts had played an average of 11.3 years and were currently playing at the Junior 'B' level. This level is two tiers below the highest, professional level in North America (i.e. National Hockey League, NHL). This is not a professional league but players from this league are drafted in to the Juniors ('As' and Major Junior) then to the NHL. Players actively compete for positions on the team. The non-experts had an average of 6.1-year playing experience and were currently playing at the 'Midget' level. This is considered to be a 'house league' recreational level of competition, whereby all players are placed on teams and there is no competition for spots. The unequal sample sizes were a result of player and coach responsiveness which limited the number of consenting players in the Midget league.

1.2. *Task and apparatus*

The games were all regular, mid-season games. In an effort to assess the underlying decision-making processes, without disrupting the natural game dynamics, we employed a video-based, stimulated recall methodology based on techniques used by Macquet (2009). This methodology has been used widely as part of the NDM approach (e.g. Housner & Griffey, 1985; Wilcox & Trudel, 1998). Players were filmed from an area adjacent to the players' bench. We also filmed the same decision scenarios from a first-person perspective, using small video cameras attached to the players' helmets (see Omodei et al., 2005). It has been suggested that this 'first person' technique aids in accurately, and unobtrusively, capturing the cues that participants focus on, providing an additional tool for researchers to use in retrospective probing (Miller, 2004). Therefore, the videos provided a prompt for assessing players' cognitive processes and, more specifically, the role of familiarity in the various decisions encountered by players during a game. In Figure 1, we have presented example snap shots of video recorded through these two techniques. These two videos provided both the player's view of the game (first-person perspective), as well as a view of the same player from an external camera (third-person perspective). No more than two players were monitored per game.

Two expert coaches jointly identified attacking decision points from the videos. The selection of decision points was based on several criteria. First, the situation had to involve a player proceeding on the attack, in control of the puck. Second, this player had to be confronted by an opposing player, with the intent of checking the attacking player in order to gain control of the puck for his team. The actual decision point was defined as the point where the attacking player had to decide what to do at the instant he was confronted by the opposing player. This could involve deciding to go around the defensive player, pass the puck to a team-mate, take a shot, turn back with the puck, etc. Two other expert coaches independently rated the quality of both the decision itself and its outcome using a Likert scale varying from 1 (poor-quality response/outcome) to 5 (excellent response/outcome). For each decision point, the initial decision quality was assessed before, and independent from, the assessment of the outcome quality. In other words, the assessors had no knowledge of the decision outcome when assessing the initial decision quality. Inter-rater reliability was determined by calculation of the (intraclass) R coefficient $((MS_S - MS_E)/MS_{S)}$ from repeated measures ANOVA techniques. There were no significant differences across the two judges (both Fs < 1) and high R values were obtained for both decision quality, $R = .83$ and decision result, $R = .76$. As a result, average values from the two judges were used in subsequent analysis of decision quality.

Figure 1. Views from the external camera that tracked player 10 (left panel) and from the helmet cam worn by the same player (right panel).

1.3. *Procedure*

1.3.1. *Videotaping*

Before the videotaped games, players provided information about their playing experience and provided informed consent. Their helmets were then fitted with a portable camera. The monitored players were aware of this procedure, and the fact that they would be required later to discuss important aspects of the game using the video from both cameras as a prompt. Subsequently, a post-game retrospective interview of approximately 30 minutes was conducted. This was conducted approximately 12 hours after the game and was always conducted by the same person. During the interview, the two videos (based on the helmet cam and the camera positioned near the players' bench), were used to refresh the player's memory about each particular decision point.

1.3.2. *Interviews*

Players were shown a specific sequence of the game leading up to a decision point. The video was then paused and the interviewer queried the player about the decision point. Players were first asked if they recalled whether the decision in question resulted in a successful or unsuccessful outcome. This was done in order to later examine the question of whether players would correlate familiarity more often with decisions they already knew to be successful. Next, the players were asked to identify whether a situation (decision point) seemed familiar or typical at the time the decision was made. A forced choice, yes or no response was required in order to obtain a relatively fast reaction as to whether the scenario was familiar. Familiarity was explained as either a specific event that had been encountered in the past that was closely reminiscent of the current situation (Klein, 1998; Macquet, 2009), or a procedure/set of rules, that they had used in the same type of situation in the past (McPherson & Kernodle, 2003). Utilising the stimulated recall protocol and retrospective interview procedures used by Klein (1998), after players had commented on the familiarity of the situation they were also asked to elaborate on why they recognised the situation as familiar.

1.3.3. *Coding*

These responses were coded by the experimenter into those that were based on recall of a previous similar event, referred to as event-based familiarity, or those that seemed familiar due to a set of procedures/rules/conditions that provided an appropriate response to the decision at hand, referred to as rule-based familiarity. Event-based familiar decisions required the player to mention recall of a previous event from the past (from the same game, or from previous games). An example of a player's response to a familiar decision that was based on experience of a previous event (in this case from the first period of the same game) was '*I was carrying the puck through the middle… coming in on this guy…in the first period I saw that he has trouble turning to the outside so that's where I went'*.

Rule-based familiar decisions required the player to describe his decision in terms of the knowledge of rules or procedures that he had learned or been trained to use in similar situations in the past, that is, remembering that under certain conditions a particular type of play is required (i.e. strategic or tactical knowledge pertaining to recognition of a particular decision point). It was necessary for these descriptions to *not* refer to an explicit event. For example, one player who reported a familiar decision of this type claimed '*our coach always taught us to move as fast as we can toward the defenseman and then when we get close we cut inside or outside to make him have to cross-over more than he might want to… so that's what I tried to do'*. It was possible for players to report judgements of familiarity based on both recognition of a previous event as well as rule familiarity, and these types of 'joint' judgements were also recorded. On a small number of decisions (4 decision points, less than 4% of the decisions), although players initially described the situation as 'familiar', they either changed their mind during the prompted interview and/or failed to make reference to recognition of a previous event, or set of conditions that would lead to that judgement '*I don't know, I thought it looked familiar…but maybe not. I can't be sure'*. These decisions were subsequently coded as 'unfamiliar' in view of our criteria for a "familiar" decision to be based on recognition of a previous event or set of procedures.

2. Results

2.1. *Number of decisions*

Between one and five decision points were jointly identified by the expert coaches for each player (experts: $M = 3.48$, $SD = .99$; non-experts: $M = 2.71$, $SD = .91$). This yielded a total of 118 decision points across all players. While the average number of decision points may initially seem low, these numbers are representative of average game conditions, where each player is on the ice approximately 15 minutes out of a 60-minute game, takes between 1 and 2 shots on goal, and is in possession of the puck for less than one minute over the entire game (USA Hockey, unpublished data).

2.2. *Decision familiarity*

When we looked at all the decision points, the expert players described decision-making situations as familiar or typical 68/80 times (85%) more often than non-expert players 16/38

(42%). However, because we were comparing across decisions, rather than participants, for analysis we calculated the modal decision response for each participant. Of the expert group, 18/23 of the modal responses were ‘familiar’, in comparison to only 6/14 for the novice group (two participants in the expert group were not included as they made an equal number of familiar and unfamiliar decisions). This difference in judgement was significant based on a chi-squared test, χ^2 (1) = 8.98, $p < .001$.

Both skill groups reported more of their judgements to be based exclusively on rule-familiarity (experts = 66.2%, non-experts = 68.8%) rather than event-familiarity (experts = 14.7%, novices = 12.5%) and both skill groups reported a similar proportion of judgements of familiarity based on both rules and events (experts = 19.1%, novices = 18.8%). An analysis of the modal athlete response confirmed this pattern of results with 16/18 of the experts’ modal decisions being classified as rule-familiar and 6/7 of the non-experts, ($\chi^2 < .1$).

Judgements of familiarity were also examined in relation to the players’ recall of the outcome of the decision in order to make assumptions about whether the judgement of familiarity was influenced by their memory of the decision outcome. Approximately 60% of all decision outcomes were recalled by the players, but there was no significant association between either event familiarity (χ^2 (1) = 0.53, $p > .05$) or rule familiarity (χ^2 (1) = .01, $p > .05$) and a players’ recall of the decision’s outcome.

2.3. ***Decision quality and familiarity***

To determine whether decision quality was influenced by the perceived familiarity of the situation, the decision points were ranked by the judges for quality on a five-point scale (1 = poor-quality decision, 5 = excellent decision) and the average rank was used in analyses. The decisions were rated according to two criteria: quality of the initial decision and quality of the outcome. We were primarily interested in the quality of the decision, but by asking for this two-category decision we were able to look at the relationship between familiarity of the situation and decision quality, as it related exclusively to the decision process, as different from the decision outcome which is typically assessed in naturalistic environments. The consequence of a decision is subject to other influences beyond the judgement of the situation as familiar, such as poor defending, puck deflection, player infringements. As would be expected, however, there was a significant relationship between decision quality and outcome, $r(116) = .70$, $p < .01$, prompting us to use repeated measures’ MANOVAs based on these two dependent measures in subsequent statistical analyses.

2.3.1. *Event-based familiarity*

We first looked at the descriptive data for all the decisions made across the two skill groups. All decisions were classed as event-familiar (experts, $n = 23$; non-experts, $n = 5$) or not event familiar (experts, $n = 57$; non-experts, $n = 33$). These data are shown in Table 1. Not surprisingly, the experts’ decisions ($M = 3.60$, $SD = 0.96$) were generally rated higher (for quality and outcome combined) than the non-experts ($M = 2.61$, $SD = 0.69$, Cohen’s $d = 1.18$). Importantly, however, ratings for the quality of the actual decision were higher for decisions that were judged to be event familiar for both the experts (difference = 0.63, Cohen’s $d = .66$) and non-experts (difference = 0.63, Cohen’s $d = .95$), with medium to large effect sizes, see Table 1. Although there was a trend for the ratings of the decision outcomes to be higher for familiar decisions for the experts (difference = 0.37, Cohen’s $d = .40$), this was not the case for the non-experts (difference = -0.05, Cohen’s $d = -0.07$).

There were 14 individuals (10 experts and four non-experts) who had both event familiar and non-familiar decisions, which allowed us to run a repeated measures’ MANOVA on the mean

Table 1. Mean (and between subject SDs) of decision quality and decision outcome (1 = poor, 5 = excellent) for all decision points identified for the expert and non-expert groups as a function of event-familiar (or not) or rule-familiar (or not).

	Decision quality		Decision outcome	
	Familiar	Unfamiliar	Familiar	Unfamiliar
Event familiarity:				
Expert	4.11(0.83)	3.48(1.06)	3.59(0.83)	3.22(1.01)
Non-expert	3.10(0.42)	2.47(0.84)	2.40(0.65)	2.45(0.84)
Rule familiarity:				
Expert	3.71(1.09)	3.55(0.90)	3.38(1.02)	3.18(0.85)
Non-expert	2.64(0.84)	2.50(0.82)	2.46(0.63)	2.44(0.91)

decision quality rating for these people (independent of skill). Based on the MANOVA the effect of familiarity was close to accepted levels of significance (Wilks $\lambda = .63$; $F(2,12) = 3.56$, $p = .061$, $\eta_p^2 = .37$). The data from this analysis are illustrated in Figure 2. Supporting the descriptive data above, the univariate ANOVAs showed a significant difference between the quality of the actual decision when it was based on a familiar previous event ($M = 3.97$, $SD = .66$) in comparison to when it was not ($M = 3.37$, $SD = .79$), $F(1, 13) = 7.71$, $p = .017$, $\eta_p^2 = .37$. Decision outcome did not statistically differentiate based on this familiarity judgement, $F(1, 13) = 1.21$, $p = .29$, $\eta_p^2 = .09$.

2.3.2. *Rule-based familiarity*

As with event familiarity, we first studied all the decisions as a function of skill. Decisions were classed as rule-familiar (expert, $n = 58$; non-expert, $n = 14$) or rule unfamiliar (expert, $n = 22$; non-expert, $n = 24$), and these data can be seen in Table 1. Again the experts were generally rated as having made better decisions (based on quality and outcome combined) ($M = 3.45$, *SD*

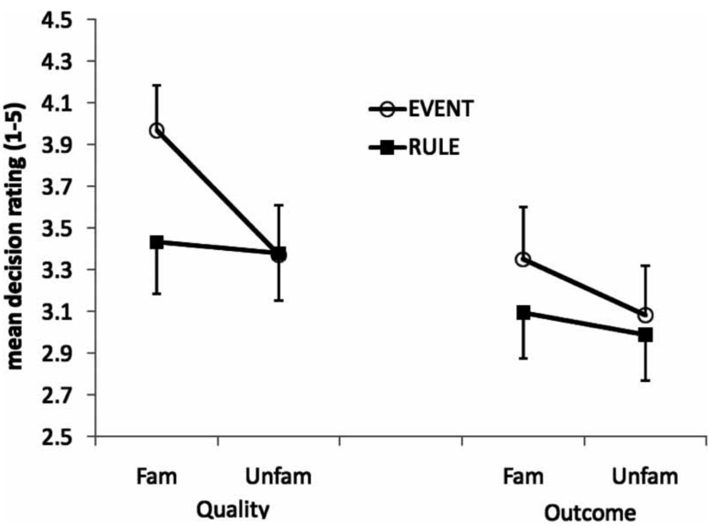

Figure 2. Mean decision quality and decision outcome (1 = poor, 5 = excellent) as a function of judgement of event and rule familiarity for all participants who had both event familiar and unfamiliar decisions ($n = 14$) and rule familiar and unfamiliar decisions ($n = 18$) (SE bars are shown).

= 0.96) than the non-experts (M = 2.51, SD = 0.80, Cohen's d = 1.06). Although there was a trend for the rule-familiar decisions to be rated higher than the rule-unfamiliar decisions (for all skill groups and measures of decision quality), the differences would be classed as small (Experts, quality = 0.16, Cohen's d = .16, outcome = 0.20, Cohen's d = .21; Non-experts, quality = 0.14, Cohen's d = .17, outcome = 0.02, Cohen's d = .03).

A repeated measures MANOVA was conducted based on the two dependent variables, decision quality and decision outcome quality, on participants who had both rule-familiar and rule-unfamiliar decisions (n =18). The MANOVA did not differentiate across decisions based on rule-familiarity (Wilks λ = .98, F(2, 16) = .20, p = .82, η_p^2 = .024). These data are illustrated in Figure 2.

3. Discussion

The purpose of the current study was to evaluate the role that situational familiarity plays in the decision-making processes of expert and non-expert athletes. Specifically, we were interested in the frequency with which experts and non-experts rely on familiarity to make decisions, as well as the nature of that familiarity (i.e. rule-based or event-based). We also explored the influence that such familiarity has on both the initial quality of the decision and the resulting outcome.

Consistent with previous research approximately 85% of all decision points were judged to be 'familiar' by our expert players. Even though we looked at a fast, dynamic sport, with many interacting components that continually change, familiarity-based judgements provided the basis of the majority of the decisions made by the skilled players. This number is consistent with those reported for expert volleyball players (90%) by Macquet (2009). As predicted, the role of familiarity in these decision processes was mediated by skill level, with the expert players being better able to retrieve previous stored memories of similar events or conditional rules in order to reach a decision, in comparison to approximately half this number of familiar decisions by the non-experts. Of these decisions judged to be familiar a greater proportion for both the non-experts and the experts were deemed to be familiar due exclusively to the recall of a familiar rule or procedure associated with the situation (~68%), rather than a judgement based on familiarity of the actual event. Again, this breakdown of decision familiarity in terms of event- and rule-based familiarity marries well with the types of decisions made by volleyball players (Macquet, 2009). Therefore, although basic pattern recognition does seem to underlie expert decisions (as well as that of less skilled players), the majority of the decisions made by skilled performers appeared to be based on more sophisticated, generative retrieval mechanisms associated with the recall of a typical situation, rather than an exemplar based familiarity of an actual event (Gobet & Simon, 1996, 1998).

A novel and important question we asked concerned the role of familiarity in the quality of these decisions. Not only is it important to determine whether familiarity is an integral part of the decision process among skilled and lesser-skilled athletes, it is also important to know whether familiarity is a process that differentiates good and poor decisions, both generally and within a skill class. If these judgements are integrally bound up in the actual response then we would expect a strong relationship between judgements of familiarity and the quality of the decision.

For the more common rule-familiarity, there was no significant relationship with the decision quality or outcome. However, for 'familiar' decisions based on event familiarity, the quality of the decision significantly related to judgements of familiarity. For all decision points the difference between familiar and unfamiliar decisions, in terms of quality and outcome, was determined to be large for the experts and of medium size, for decision quality only, for the non-experts. Although not surprisingly the expert players were rated by the coaches as displaying better-quality decisions, both in terms of the actual decision and its outcome, skill level appeared to only have a moderate influence on the association between decision quality and judgements of familiarity. We probably would not expect to see skill dependencies here if it were indeed the case that pattern recognition skills underlie good or better-quality decisions. Subsequent study is required, probably under more controlled conditions, in order to further confirm this hypothesis, with larger sample sizes that allow comparisons across skill class for both types of decisions. Therefore, it appears that whilst familiarity-based decision making is common, only when this familiarity is based on the recognition of a previous event does it show a relation to decision quality. Further, there was little evidence of a relation between event-familiarity and the quality of the decision outcome, suggesting that these judgements of recognition lead to good decisions, as determined by expert coaches, but not necessarily good outcomes (although decision quality and the quality of the outcome were highly correlated).

Of course, with this type of observational design there is the question as to whether (event) familiar situations are actually of better quality, or rather, that when a 'good' decision is made, it is more likely to be perceived as 'familiar'. In relation to this point it is important to note that the players did not have knowledge, via the videos, of the outcome of the decision points discussed during the post-game interview. Although it is possible they remembered the outcome of the decision, there was no relation between judgements of familiarity and recall of the decision outcome. Therefore, we think it is likely that familiarity with the scenario was responsible for the better-quality decisions.

In general, these findings corroborate and complement much of the laboratory-based work on the role of pattern-matching (familiarity) in expertise, whereby recognition of perceptual events serves to guide fast and accurate decisions (Ericsson & Kintsch, 1995). Although it seems that rule-based familiarity, arguably a more semantically driven process (consisting of plans, tactical and strategic features), underlies significantly more of the decisions made by skilled and less-skilled players (see Gobet & Simon, 1996; Holding, 1992; McPherson & Kernodle, 2003), this type of familiarity is not reliably related to the quality of the decision. Moreover, it has been known for some time that experts are better able to recall game-specific, structured as well as non-structured plays more effectively than their less skilled counterparts, speaking perhaps to the importance of these (rule-based) generative processes in perceptual recognition (Hodges, Huys, & Starkes, 2007).

Interestingly, in recent work looking at the relationship between pattern recognition and decision quality in soccer, evidence has been presented showing that the relationship between these two processes is not as strong as originally proposed. North, Williams, Hodges, Ward, and Ericsson (2009) (see also North, Ward, Ericsson, & Williams, 2011) failed to find a significant relationship between anticipation accuracy and recall of the same previously viewed clips for skilled players. Moreover, the visual search strategies employed differed quite markedly when anticipatory decisions were required in comparison to a recall judgement. Therefore, although feelings of familiarity do underlie decision processes, they are not necessarily integral in the final decision or in the quality of the decision. This is important in view of theories of decision-making that posit a one-on-one relationship between perceptual familiarity and the response (e.g. Klein, 1998).

Earlier we discussed a model of decision making whereby decision quality is enhanced if the first decision that comes to mind is chosen (Johnson & Raab, 2003; Raab & Johnson, 2007). This model also carries the assumption that retrieval structures associated with judgements of familiarity are tied to a specific 'optimal' decision. Support for this line of thinking has come from research based on the role of *intuition* in decision making. Intuition is generally considered to be a quick, somewhat unconscious judgement that arises from previous experience. In a study comparing decision quality and speed in experts and non-experts, Raab and Laborde (2011) found that experts tended to be more intuitive in their decision making, producing better quality and faster decision responses than non-experts. The previous experience that is said to result in better intuition may manifest itself through the types of situational familiarity that we have studied. That is, situational familiarity may help to cultivate intuitive capabilities. Although the number of decisions considered, or the time to make the decision, was not something we measured, it might be argued that when a less semantic, perceptually driven familiarity process is called upon or available to aid decisions, as would be the case with event-familiarity, there is a tighter relationship between the retrieval and response processes, resulting in a quicker, more intuitive decision process (see also Ferrari, Didierjean, & Marmeche, 2006). In contrast, for decisions that rely more on rule-based familiarity, these decisions might be slower, resulting in less-intuitive, more evaluative processes (see North et al., 2011), and as such a better quality decision does not necessarily ensue. However, this line of reasoning is quite speculative and there is need for researchers to study the potential differences between event- and rule-based familiarity, in terms of their influences on intuitive and evaluative processes, and their impact on decision speed and quality.

Recent behavioural and neurophysiological findings have begun to shed light on the neural underpinnings of the expert advantage with respect to familiarity. In several studies comparing the abilities of experts and novices to make recognition- or anticipatory-based decisions, it has been shown that it is the experts' *motor* familiarity with the situation, not their *perceptual* (visual) familiarity, which allows them to perform at such a superior level (e.g. Aglioti, Cesari, Romani, & Urgesi, 2008; Calvo-Merino, Grezes, Glaser, Passingham, & Haggard, 2006). Therefore judgements of familiarity in sport, likely come about through extensive experience performing in similar situations (i.e. sensory-motor representations), rather than just a sensory recognition.

Finally, these results may have important implications for athletes and coaches, in terms of the design of training and practise protocols. The current training paradigm in ice hockey, and other team sports, places a high emphasis on verbal and written descriptions of discrete procedural (rule-based) scenarios, with less emphasis on developing a player's repertoire of game-like (event-based) analogues. For example, it is usual for a coach to draw up a two-on-one attacking play, explain the technique to the players, and then have two forwards and a defenseman practise this scenario repeatedly. Conversely, while coaches sometimes allow time for short game-like scrimmages during practise sessions, these usually come at the end of the session, and are rarely used in any instructive manner. In light of our findings, showing at least some advantage for event-based analogues in decision quality, it may be prudent for coaches to expose players to more game-like scenarios during teaching moments. While we fully understand that these techniques are currently utilised by some coaches, our results may provide new evidence supporting their effectiveness.

In conclusion, we have presented evidence showing that familiarity-based decision judgements are common in fast dynamic sport environments and that these verbalisable judgements show some evidence of being moderated by skill. Rule-based familiarity appears to be the more common type of familiarity judgement, but there was no evidence that these types of judgements were related to the ensuing decision quality. Only for decisions that were judged to be event-familiar were the subsequent decisions deemed to be of better quality in comparison to those decisions not based on event-familiarity. This pattern matching aspect of the decision making process as it relates to decision quality has not previously been examined in dynamic, sport-based environments. Moreover, because we used a framework of field-based observation, helmet-cam technology, and retrospective interview procedures, we were able to preserve the relationship between perception and action in order to study in situ decisions and hence add to our understanding of the processes which mediate fast and accurate decisions during competitive sports play. Admittedly there were still potential issues with our chosen methodology, related to the number of decision points, the retrospective nature of decision probing and differences between individuals with respect to decision points that were judged to be familiar and unfamiliar (beyond skill-level differences). Nevertheless, we have provided data consistent with current thinking about decision making in skilled performers, as well as providing theoretical considerations about the relationships between familiarity judgements and subsequent responses as a function of the type of familiarity (event or rule) underlying that decision.

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