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**Making Sense of Chaos: Decision Making by High and Low Experience Rugby Referees**

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**Submitted to the School of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Arts in Human Kinetics**

**Ottawa, Ontario, Canada, 1999**



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## Dedication

I dedicate this work to my parents, Marie-Therese and Bernard Mac Mahon, for all the dedication they have shown towards me. Thank you.

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Seneca said about those who say that the things they cannot do cannot be done: ***“It’s not because they’re hard that we lose confidence, they’re hard because we lack the confidence.”*** I often didn’t have the confidence that I needed to do this difficult task, and because of this, there are people who became essential in its completion. Diane Ste-Marie was the best advisor I could have had, and an excellent, balanced role model. I thank her for giving me freedom and independence to sort things out and then always having her door open for innumerable “quick questions” when the freedom scared me. Thank you, also, to my lab group over the two years: Kavita Prakash-Mosher, Gail Taylor-Peever, Jennifer Cumming, Gina Bottamini and Amy Latimer.

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When I take this thesis down off the shelf, I hope I remember all that I experienced, the good and the bad, and the lessons I learned, because I am grateful that I learned so much, both academically and personally.

***"Those who have the will to win cannot be beat".***

Good. Done.

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## Abstract

The purpose of this thesis research was to investigate the decision making of rugby referees. Based on past research, concepts felt to be important in this task were anticipation, and knowledge base. To investigate these features for referees, the expertise paradigm was incorporated. Thus, 12 high and 12 low experience referees were asked to evaluate clips of videotaped rugby footage for infractions. Participants were asked to anticipate upcoming actions and calls, and their ability to detect infractions was measured along with voice reaction time (VRT). In addition, referees were asked questions related to their knowledge bases, and the information sources from which they drew in performing this task. The responses to the videotaped plays were analysed using signal detection theory (Macmillan & Creelman, 1991) and revealed no significant group differences. Further, a two-way analysis of variance performed using the information sources data revealed significant differences between the high and low experience referee groups. Further sections discuss data collected on anticipation, VRT, and another measure of knowledge, that were eventually eliminated from the study. This and other related features led to a final section describing common characteristics and defining characteristics for the general population of sport monitors.

## Organization of the Thesis

The presentation of this thesis is organized into four sections. In the first main section, an introduction is provided that sets up the general issues in the thesis. Also in this section is a literature review, which begins with a description of rugby football, as both committee members suggested its inclusion at the proposal meeting. Finally, this section contains a justification of the population, hypotheses and acknowledged limitations. The second section consists of a journal article which has been prepared for submission to an academic journal, and thus appears in the required form. Elaborated results and discussion is the third section which presents material and conclusions generated from this research that were not presented in the article.

The final section of the thesis is the appendix. In Appendix A, the relative contributions of the two journal article authors is detailed. Appendix B presents an example of a participant consent form, and Appendix C of a videotaping consent form. Appendix D is a copy of the instructions used during the data collection of the study, and Appendix E is a copy of the instructions given to the expert video raters. Appendix F is a list with descriptions of the codes and clusters used in data analysis, and finally, Appendix G, is the documentation of ethics approval for this study.

**SECTION I**



## Introduction

Sport refereeing is a demanding task requiring fast and accurate decision making skills. Research in the sport domain thus far has emphasized the perspectives of the athlete and the coach, while the perspective of the official has been neglected. The role of the official, however, is crucial in affecting the outcome for many sports, and thus should also be examined.

Describing refereeing as a decision making task makes it particularly relevant to consider current trends in this area of research. For example, decision making research has recently shifted from investigations using classical models to those incorporating naturalistic models. While classical models describe obtaining a correct response through the use of a formula or set of rigid rules, naturalistic models acknowledge a number of changing features of the task and the task environment which can affect the response chosen (Orasanu & Connolly, 1993).

Naturalistic decision making models acknowledge situations in which a decision maker is confronted by an unclear, undefined problem. These models acknowledge features such as ill-structured problems, uncertain dynamic environments, action/feedback loops, time pressures, and high stakes. A clear link will be shown between these features and the context of the rugby referee, necessitating a review of the literature from naturalistic models of decision making.

Interestingly, current models of naturalistic decision making make reference to many of the same concepts as those used in the sport/cognitive expertise literature. For example, naturalistic models emphasize the importance of domain specific knowledge and experience in decision making (Hammond, 1993; Klein, 1993; Rasmussen, 1993).

Similarly, in a review of the literature by Allard and Starkes (1993), these two components were emphasized as important elements in sport expertise. Although these two research bases discuss similar issues, the integration of the two fields was not apparent in the literature search. Moreover, it is thought that the combination of the two is very appropriate for sport decision making investigations. Specifically, the expertise paradigm is argued to be a useful tool for investigating decision making processes. While there are many approaches and dimensions in expertise research, the two factors of anticipation and knowledge base will be the focus here. The importance of these factors will become clear in a description of the game of rugby football, and the task requirements of the referee.

In the remainder of this introduction, then, the key aspects from naturalistic decision making literature, as well as the relevant areas of cognitive expertise research and its development into the sport area will be reviewed. The factors of anticipation and knowledge base, deemed especially relevant here, will thus be highlighted. The population of rugby referees will be justified in terms of how the preceding context is linked with their task demands. After discussion of the method, the research hypotheses will be presented based on the literature, and the data analysis techniques will be reviewed. The introduction will conclude with the presentation of limitations of the study and how these have been addressed. First, a description of rugby football and the role of the referee is provided.

### Description of Rugby Football and the Referee

Aspects of the game of rugby football relevant to the present discussion will be presented. As well, the three main types of actions selected as stimuli in this study will

be described (i.e., tackles, kicks and lineouts). A rugby team consists of 15 players a side. The object of the game is to score more points than the other team by carrying, passing, kicking, and touching down or grounding the ball in the in-goal or end zone area. The game begins with a kickoff from the midway line. The ball may move forward only by being carried, or by being kicked or propelled through contact with the body below the hips. Forward passes are not allowed, therefore, a pass must be lateral or backward.

When the ball or the player carrying the ball goes over the line of touch, or sidelines, the ball is put back into play with a **lineout**. Each team lines up from two to seven players one behind the other facing the sideline with a gap of one metre wide between the two teams. The ball is thrown down the centre of the two lines by the team which did not take the ball out of bounds. Both teams then attempt to gain possession of the ball by having designated players jump up to catch it. While these players jump, they can be supported about the waist by two teammates.

A referee watches for four main types of infractions at the lineout. An example of an “along the line” infraction is when the ball being thrown along the lineout is not thrown straight, but towards one team giving them a better chance of catching it. It is also illegal for a player to “submarine” another player who is jumping in the lineout. This would be an example of an infraction “through the lineout”. An “across the lineout” offense is exemplified by a player supporting a jumper incorrectly. Finally, the fourth type of lineout infractions are “outside the lineout” offenses. This is where the referee is concerned with players who are not participating in the lineout. In this case a player may have advanced over the offside line and be in an illegal position.

While the ball is in open play, a player may **tackle** to the ground an opponent who is in possession of the ball. It is illegal, however, to tackle a player not in possession of the ball, or to tackle a player dangerously as in the case of wrapping around a player's neck. Once tackled, a player must release, or place the ball on the ground and get up or roll away. A referee is thus concerned with the actions of the tackler and tacklee during the tackle. The referee thus watches a tackle while it is going to ground, and once the tacklee is on the ground. Another area of concern for the referee in the tackle is the action that ensues afterward. The "third man in" must enter the ensuing formation legally.

**Penalty kicks** and **free kicks** are awarded for infringements of the laws, with free kicks for minor offenses, and penalties for major offences. The difference between these two is that penalty kicks may be used to kick at goal and score three points, whereas a free kick cannot be used to score. In performing a kick, a player need only propel the ball forward a visible distance. A kick can thus be turned into a passing play when a player "taps" the ball from the foot into the hands before passing the ball out. In a penalty kick situation, the referee looks for the opposition to be back the required 10 metres from the mark where the kick was awarded. The kicking team must be behind the kicker, and in the case where a player performs a tap kick and then passes the ball, laws control the formation and advancement of the offensive team. As mentioned, the other types of kicks are place kicks for the start of the game, the restart in the second half, and a restart after a score. These kicks are also regulated in the positioning of the offense and the defense, as well as the type of kick, the distance it must travel, and where it lands. Two other types of kicks will be reviewed in the next section.

A **try** is similar to a touchdown in football, and is awarded for touching the ball down to the ground in the opponent's **in-goal** area, or end zone. Tries are worth five points, and the **conversion** kick between the goal posts, which takes place after a try, is worth two points when successful. In the open field of play, a player may **drop kick** the ball through the uprights for 3 points. In a drop kick, the ball is released, and must touch the ground and be rebounding upwards before being kicked. Finally, when the referee feels that a try would have been scored if not for foul play, a **penalty try** of five points may be awarded.

In the game of rugby, there are two touch judges and one referee. The touch judges remain on one of either touch line marking the place at which the ball or player carrying the ball has crossed the line and indicating which team will have possession to throw the ball in at the lineout. The referee follows the flow of the game on the field and positions him or herself in order to see infringements while not interfering with the play. Referees keep track of the game time and the score, in addition to the many laws of the game and their interpretations. The referee is the focus of the present study.

The rugby referee is considered the "...sole judge of fact and Law..." (International Rugby Football Board Handbook, 1997, p.124), and is expected to apply the Laws of the Game consistently and without variation. To do so, a referee in a rugby game must monitor the actions of the 30 players who are often in very close proximity and concealing the ball. The referee must constantly be aware of his/her position on the field and avoid obstructing the play while keeping track of the score and the amount of time elapsed. In addition, referees must apply the advantage law wherein the awarding of

a penalty or scrum to the non-offending team will be delayed until such time as the team that has not caused the infraction gains either a strategic or positional advantage.

## Literature Review

### Naturalistic Models of Decision Making

In a recent review of naturalistic decision making models by Orasanu and Connolly (1993), it was noted that the features of naturalistic decision making settings include time pressures, ill-structured problems, uncertain dynamic environments, action/feedback loops, ill defined goals, high stakes, and the organizational context. Obviously, each of these features results in varying problems for the decision maker. At the same time that features of the problem are recognized, characteristics relevant to the decision maker are also acknowledged. Naturalistic models, for example, acknowledge that the human processor suffers difficulties arising from fatigue, stress, and limits in capacity. Further, Orasanu and Connolly (1993) stated that these models allow for the fact that there are several ways to arrive at an answer, and that there may, in fact, be more than one answer to a given problem or decision making task. Moreover, different decision models have been used to fit the specific tasks of the particular decision making being described.

In another review of nine naturalistic decision making models, Lipshitz (1993) provided a good description of their important aspects. The models described had different methods for making real world decisions such as recognition based, dominant alternative based, as well as analytical versus intuitive based methods. Differences in the models arose from the differences in the types of decisions examined. In fact, decision type often drove the models. The decisions described ranged from dealing with a forest fire, to choosing an apartment, to handling a systems breakdown in a power plant.

Although each model had various differences, Lipshitz revealed common underlying trends.

First, Lipshitz (1993) discussed the fact that common to the nine models was the process of situation assessment. Whether the situation was assessed before or simultaneously with the decision making process, each model did include an evaluation of the situation. The use of mental imagery was also a common theme in the models. Decision makers were described as imagining the situation unfolding, given a decision choice. This was the case whether imagery was invoked through the process of categorization, or the use of existing knowledge structures, or through the use of other cognitive processes.

Also notable was the variety of models presented as indicative of the decision making field. Lipshitz (1993) contended that this diversity of form acknowledged the futility of attempts to choose one model that applies to every situation. Rather, the applicability and efficacy of a model was said to depend on the decision being studied. This was directly linked to another trend that was highlighted, that of context dependence. The situation in which a decision must take place was said to have an effect on the process of decision making. To illustrate, recall the examples of choosing an apartment, dealing with a fire, and addressing a power plant systems failure. Each of these contexts may be familiar or unfamiliar to a decision maker, and may need either a quick decision or a more time consuming analysis.

From the sport literature, Trudel, Dionne and Bernard (1999), as well as Gilbert, Trudel and Bloom (1995) further emphasized context in decision making. In assessing ice hockey penalties, Trudel and colleagues concluded that referees, as compared to



coaches, players and parents, attached greater importance to the context in which the infraction had occurred. Providing examples of possible situational considerations, Gilbert et. al. revealed that both the score of the game and the time remaining were shown to influence decisions related to penalty assessment. That is, decision making was described as occurring as a function of the context. This point will resurface later when identifying the model seen as most appropriate for rugby refereeing.

Another aspect related to the features of context dependence and diversity of form within the models was the commonality of emphasizing the dynamic quality of decisions. Decision making processes must adapt to the functions of the changing task requirements, which is precisely why there is a diversity of form and context dependence. Finally, Lipshitz (1993) noted that a shift had been made from the classical model notions of prescribing a systematic, diagnostic model to that of a description-based prescription. That is, the models did not set out to explore how decisions *should* be made, but how decisions *are* made. Given this orientation, one guideline proposed by Lipshitz was to begin development of description-based prescriptions.

Towards developing description-based prescriptions, Lipshitz (1993) argued for the importance of examining expert performance. He stated that “the development of description-based prescriptions begins by studying how experts make decisions in their areas of expertise and then developing methods for improving decision quality...” (p. 134.). Such a statement brings to light the obvious relationship between the literature bases of expertise and decision making. This relationship will be elaborated upon in a later section of this thesis. First, specific decision making models and their contributions to this thesis will be treated.

After reviewing the nine models from the perspective of conducting research, the task became one of choosing a model with which to frame the investigation. To begin, the typological models were used to define the nature of the referee's tasks more clearly. In that light, Hammond's (1993) model incorporating the cognitive continuum theory, as well as Rasmussen's (1993) cognitive control of decision processes model proved useful, and will thus be briefly described.

Hammond's (1993) model is used to describe how decision processes change as a function of changes in the decision task or environment. Specifically, Hammond discusses the use of an intuitive, as contrasted with the analytical process. Intuitive decisions are characterized by low control, low conscious awareness, rapid data processing, high confidence in the decision choice and low confidence in the method for arriving at a decision. Decisions made through the use of analysis, however, have the opposite characteristics, such as conscious control and a slow deliberate process.

Further, the nature of the task induces the type of decision making used. Intuitive decisions are prompted when confronted with large amounts of information in a short duration. Conversely, an analytical process will be engaged when slow data processing and high cognitive control are required. When the use of careful analysis is failing, however, a decision maker may begin to make intuitive decisions, and vice versa. The use of one process, however, does not exclude the use of the other. The mixture of analysis and intuition was termed a quasirational process. In considering refereeing, the constraints of the task suggest that a model relying much on an intuitive, quasirational-based process would be appropriate.

Rasmussen's (1993) model was also determined to be pertinent, as it described the cognitive control of decision processes as being carried out by different cognitive mechanisms dependent upon three types of decision making behaviors. The three types of behavior were skill-, rule-, and knowledge-based. Skill-based decision making was said to include sensorimotor performance, and had many of the same features as Hammond's (1993) intuitive processing. For example, skill-based behavior was described as those behaviors that run effectively in the absence of conscious control, and of those controlled by a dynamic mental representation depicting the movements and the environment in real time.

The second category of decision behaviors put forth by Rasmussen's (1993) model is that of rule-based behaviors. These behaviors are controlled by rules that can be explicitly stated by the decision maker in the context of an association between a cue and the appropriate task. The determination between whether skill- or rule-based behaviors are being executed depends on the extent to which the task is executed automatically or attentively. A relevant point here though, is that both rule- and skill-based behaviors are enacted in familiar situations. Novel situations, however, rely on the third category of knowledge-based behaviors. Knowledge-based situations, then, require a more abstract and labored approach. Focus is placed on specific components of the information being processed, which is then structured into the entire situation. Thus, for knowledge-based behaviors, more explicit considerations of the objectives and possible options need to be made.

Whether a situation is familiar or novel, and thus whether skill- and rule-, or knowledge-based behaviors are enacted is largely a function of expertise in a given

domain. In considering refereeing, more situations are novel to a novice or low experience performer than to an expert. A novice, then, will function using primarily rule- and knowledge-based decision behaviors, whereas an expert or high experience performer will predominantly employ skill- and rule-based behaviors.

In considering refereeing within the context of Hammond (1993) and Rasmussen (1993), the task characteristics become relevant. Referees are confronted with time pressures and a great deal of information. This situation often dictates rapid data processing. Intuitive decisions thus predominate, however, there may be opportunities for analysis. Decisions are based on formal training and past experience. Action or decisions are triggered through the recognition of signals and matching of cues to an associated response retained from experience. Putting both of the models together classifies the tasks as quasirational, with skill- and rule- based decisions, with some incorporation of knowledge-based behaviors, as mentioned, in the case of the novice. The process of making these types of decisions can now be discussed through Klein's (1993) recognition-primed decisions model.

Of the nine models presented by Lipshitz (1993), Klein's (1993) recognition-primed decisions model was deemed to be the most applicable to the sport refereeing context. Klein's model emphasizes decision making while under time constraints, incorporates the situations linked to a quasirational process, and proposes that novel situations are assessed differently. Klein also adopts the favoured traditional cognitive paradigm that includes information processing stages, much like that which will be presented in this thesis. Finally, Klein (1993) developed his model using expert firefighters and focused on the nature of how expertise impacted on their decision making

processes. This is very much in line with the rationale that will be presented in this thesis. For these reasons, Klein's (1993) model will be discussed in more detail.

When encountered with a decision task, Klein (1993) describes the decision maker as first going through a three phase process of option selection. The first phase is situation recognition, where an encountered situation is classified as either typical or novel. This classification is then used to establish the goals of the decision. Once goals are set, the decision maker engages in the next phase of serial option evaluation wherein options are evaluated beginning with the most typical and progressing to the least typical.

Having chosen an option from the decision queue, Klein's final phase of mental simulation is used to evaluate the merits of the choice. Steps in implementing the choice are imagined, as are results and potential problems along with their potential solutions. This simulation results in the implementation, modification or rejection of the choice. The use of mental simulation is presented as a strategy which guards against mistakes. In considering expert-novice decision making differences, however, it is expected that the first option created by the expert is the best option. This process then reduces the time strain of what, for a novice, would be a lengthy process.

Klein (1993) further argues that the initial selection of a decision is primed as a prototype that has been generated from previous experiences. Using critical cues, the decision maker then attempts to match the situation to one of many existing prototypes. It is expected that experts, because of their domain specific knowledge, easily generate a match. For example, a rugby referee observes a player being tackled. In order to determine whether the tackle is legal or not, the prototype of a legal tackle is primed from memory. The prototype uses the cues of the tackler wrapping around the runner's waist

from an angle directly in front of the runner. Using these cues and matching to what has been observed, the referee decides very quickly that the tackle is legal, and chooses not to make a call. Although making the decision may seem simple to an expert, the novice referee may find difficulty in the distractions present. The expert deals with these distractions by decreasing information overload and confusion through focusing on critical cues and identifying causal factors.

Using Klein's model, McLennan and Omodei (1996) explored an additional component that they thought should be considered; that of prepriming. The idea presented was to address the limitations of applying Klein's model to situations such as basket ball and football, wherein decisions must be made instantaneously, with restricted time for the situation identification processes proposed. McLennan and Omodei additionally felt that situations such as those encountered by fireground commanders offer decision tasks in which awareness of a situation may precede encountering the situation. That is, in traveling to a fire site, opportunities for pre-priming are presented. For example, given the information that the fire to be encountered is in a highrise building, prepriming of prototypes was expected to take place. Upon arrival at the site, situation recognition and additional priming were then expected.

In a second portion of the same study, the notion of instantaneous decision making was explored using Australian Football League referees as participants. The referees wore a head-mounted video camera in order to obtain the play from their point of view. The footage was subsequently employed for stimulated recall of match decision making. The authors determined that referees engaged in very rapid decision making requiring less than one second. It was argued that mental simulations of likely events

aided this rapidity. That is, referees' mental simulations of events which they felt might occur (i.e. were preprimed), increased the rapidity of their responses when the event actually did occur. These mental simulations were referred to as active anticipatory simulations, and were presented as a strategy used to successfully deal with the time constraints of the decision making task. This hypothesis, however, was not tested empirically by the authors.

In summary, naturalistic decision making models provide an excellent vantage point from which to view decision making in referees. In order to choose an appropriate decision making model, both the decision maker and the decision task must be examined. Hammond's (1993) and Rasmussen's (1993) models served to frame refereeing as a quasirational, intuitive, and primarily rule-based task. In addition, in order to describe the process of making decisions of this type, Klein's (1993) model proved highly applicable.

Noteworthy here is the emphasis placed on the role of domain specific knowledge within Klein's model. McLennan and Omodei (1996) also suggest the influence of anticipation. Interestingly, these notions of anticipation and knowledge base are often studied in the field of expertise within sport (Abernethy, Neal, & Koning, 1994; French & Thomas, 1987; Starkes, 1987; Tenenbaum, Levy-Kolker, Sade, Lieberman, & Lidor, 1996; Thomas & Thomas, 1994). The two literature bases of sport expertise and naturalistic decision making do not, however, appear to have been integrated to date, and it may be productive to do so. That is, the general understanding of cognition in sport from the expertise perspective could contribute to the understanding of decision making. In addition, the two specific areas of anticipation and knowledge base are of particular relevance. As a result, the subsequent sections develop the areas of cognitive expertise

for the purpose of setting a foundation for the method. This is followed by more specific information of the relevance of anticipation and knowledge base.

### Cognition and Expertise

Klein et al. (1993) argued that examinations of individuals who are very knowledgeable in a given domain help to elucidate the decision processes being undertaken. This statement is echoed in Ericsson and Charness's (1994) analogy that to understand the maximum speed a human being can run, one would look at the fastest runners throughout history. Examining running speed overall, however, requires knowledge of average speed for comparison as well as for revealing development to the fastest speed. Similarly, understanding overall *functioning* of decision making in a domain requires knowledge of both optimal and average or less than average performance. That is, experts are considered to be in possession of the relevant knowledge and tools used for optimal functioning in a given task. Discovering such tools and comparing them to those of novices may contribute significantly to an understanding of the structure and development of optimal decision making. The incorporation of the expertise paradigm is thus deemed an appropriate method for studying decision making processes of the official.

The study of cognitive expertise has produced a large body of literature. Preliminary research in the thinking and processing of patterns dealt with performance in chess (Chase & Simon, 1973, de Groot, 1965). This paradigm was soon transferred to other areas, such as physics (Newell & Simon, 1972), and, of particular relevance here, the sport domain (Starkes & Deakin, 1984).



Examining performance in sport (Starkes & Deakin, 1984) revealed parallel findings to those in the areas of chess and problem solving. The expertise paradigm has thus become a frequently used technique to learn more about excellence in sport (French & Thomas, 1987; Garland & Barry, 1990; Klein & Hoffman, 1993; Russell & Salmela, 1992; Ste-Marie, 1998; Thomas & Thomas, 1994). From this research, a number of findings have emerged and, for brevity's sake, two that are more directly connected to this proposal will be introduced. The first is related to hardware and software abilities and the second to the specificity of cognitive expertise.

Starkes and Deakin (1984) used expertise research in distinguishing between hardware abilities and software abilities. Hardware abilities are considered those which rely on perceptual skill in processing features of the stimulus (Abernethy, 1987). An example of the view that the expert advantage rests in hardware abilities is the view that a soccer player with wide set eyes will have improved peripheral vision, thus facilitating the development of expert scanning. Software abilities in contrast deal with the processing of information received through the hardware systems. In the instance of the soccer player, the advantage may rest more in terms of the athlete knowing where to look at the appropriate time in game play.

Early examinations of expertise focused on hardware components, revealing only moderate to low correlations between those measures and sport skill (see Abernethy review article, 1987). In contrast, the software or cognitive components have been shown to differentiate between more and less skilled athletes. It is shown, then, that although experts and novices have the same hardware capabilities, the processing is where the advantage lies. Starkes and Deakin (1984) summarize this in stating, "...the skilled

athlete selects processes, and retrieves game structured information in ways very different from the novice” (p. 114). As mentioned, these findings paralleled those found in the early expertise research with chess players (de Groot, 1965; Chase & Simon, 1973) and problem solving tasks (Newell & Simon, 1972).

The second major category of findings in cognitive expertise research deals with task specificity. Although experts have been shown to excel at cognitive tasks associated with their domain of expertise, this advantage does not transfer to tasks unrelated to performance. Chess masters, for example, revealed superiority for recall of chess pieces which conformed to an actual game position, but not for game pieces arranged randomly (Chase & Simon, 1973). Similarly, differentiation between expert and novice sport performers has been found to exist only on measures of sport specific cognitive functioning (Abernethy, 1991; Abernethy, Neal & Koning, 1994; Bard, Fleury & Goulet, 1994; Garland & Barry, 1990; Klein & Hoffman, 1993; Ripoll, Kerlirzin, Stein & Reine, 1995; Thomas & Thomas, 1994). For example, Garland and Barry (1991) tested expert high school football coaches in recall and recognition of structured and unstructured stimuli. The domain specificity of the expert advantage was shown by superior performance in the structured condition, but not in the unstructured condition. If it were the case that the experts benefited from overall superior recall, an advantage would have been shown in both conditions rather than solely in the condition which relied on game knowledge.

A procedure used by Ripoll et al. (1995) in examining problem solving in boxing highlights another factor of importance when studying expert-novice differences. In that study, expert and novice boxers viewed a video screen displaying a boxing opponent as

filmed from a front angle. This view was used to replicate the angle typically viewed when facing an opponent from within the boxing ring. The video opponent presented problem situations in the form of typical boxing maneuvers to which the participant responded. Situations were classified as simple and complex as a function of the types of stimuli presented. In a simple situation, the video opponent presented stimuli from only one type of maneuver classification. The complex situation, in contrast, presented stimuli from two different types of maneuvers. No effect of expertise was found for performance in simple situations, however, differences were found for the complex ones. Increasing situation complexity, thus, lends itself to revealing increased expert-novice performance differences.

In light of these considerations, the method employed here will be to present edited video sequences of real game play to rugby referees. They will be asked to answer a number of questions related to the footage that will elucidate how decisions were made. In this way, the task is domain specific, related to processing strategies, and of a complex nature. Further, although this method is not the real task encountered by referees on the field, Weinberg and Richardson (1990) encouraged referees to practice making calls while watching game film. This advice can be used to support the claim that the use of videotape is a useful simulation. Still to be discussed, however, is what aspects of the decision making process are going to be studied. The rationale for this is presented in the next section.

Ericsson, Krampe, and Tesch-Romer (1993) argued for the “10-year rule” of attainment whereby at least 10 years of experience is expected in a given domain before expertise is attained. Over the course of these 10 years, the expert is expected to have

engaged in 10,000 hours of deliberate practice. Thus, at a very rudimentary level, we know that experts obviously possess greater experience than do novices. The question then becomes, what does this experience serve to do? The factors of anticipation and knowledge base are two factors that have been shown to highlight expert-novice differences and have been related to the expert advantage (e.g., Abernethy, 1991; French & Thomas, 1987). These two factors were both addressed in the decision making literature review, and are here expanded upon within the expertise framework.

### Anticipation and Decision Making

Researchers have often examined anticipation as an important factor in expertise. In reviewing that literature, Tenenbaum et al. (1996) noted that efficient decision making was a derivative of early recognition of cues and patterns. Findings have shown that experts use shorter viewing times for cue identification, and need less visual information in order to make a correct decision (Abernethy, 1991; Bard et al, 1994). For instance, in addressing the paradox that skilled performers appear unhurried in what is assumed to be a time-constrained decision making task, Abernethy showed that expert badminton and squash players, in contrast to novices, make better use of advance cues that are available in the environment. Abernethy argued that appropriate use of advance cues allows the decision maker to prepare mechanisms such as schema activation before their actual use. Thus, when the decision choice must be made, time is no longer needed for activation of these mechanisms, and more time can be devoted to the decision making choice process. Time constraints are consequently reduced, and the decision making task is facilitated.

This same logic was used by Ste-Marie (1998) in her study of expertise in gymnastics judging. Expert gymnastics judges showed better anticipation than novice

judges. In addition, overall, judges were also better at evaluating a gymnastics move that had been correctly anticipated. In line with Abernethy's claims, Ste-Marie proposed that more resources were available for the task of evaluating the performance at the decision making moment or event. This view acknowledges influences such as prior experience, situation characteristics and situation recognition, as well as the physical and mental state of the decision maker. In short, all of the processes and influences leading up to the decision are included as part of the task.

The use of anticipation is thus illustrated in the tasks of playing racquet sports, and gymnastics judging, and can also be applied to tasks faced by rugby referees. Watching the actions of the players, a rugby referee can use important cues to anticipate upcoming plays. For example, when a referee correctly anticipates a kick up field he or she will begin to move towards where the ensuing action will take place. Being correctly positioned for the next actions will create a situation whereby subsequent actions are more optimally viewed by the referee, contributing increased information and aiding decision making. Additionally, using the cues can also activate schemata in advance of an action, easing time constraints. For example, in viewing a player turning to pass the ball, the referee notices that the ball carrier is targeting a player in an offside position as the receiver. The prototype of an illegal pass is activated from these cues. When the pass occurs and is in fact illegal the decision to call an infraction is made quickly due to the advanced processing that took place when correct anticipation was used. Anticipation thus becomes important in the context of rugby as a fast ball game with an abundance of competing cues.

## Knowledge Base

In examining the locus of the expert advantage, many studies have focused on knowledge base (French, & Thomas, 1987; Russell, & Salmela, 1992; Thomas & Thomas, 1994). These have been examined using the categories of declarative, procedural and strategic knowledge. Briefly, procedural knowledge is “how to” knowledge, as shown in knowing what action to perform in a given situation as well as how to carry out that action. Declarative knowledge refers to the knowledge of rules and facts which pertain to the particular event. These two categories are very much in line with the skill- and rule-based decision behaviors referred to by Rasmussen (1993). This is another example of how the two research areas have run in parallel with little linking. Again, within the task of rugby refereeing, the task of the referee is to ensure that the athletes implement the laws of the game. Obviously, this requires up to date knowledge of these laws. Finally, the less often used category of strategic knowledge refers to knowledge of methods that can be used to achieve an action or goal. For example, the knowledge that using rehearsal to recall a phone number is a helpful technique constitutes strategic knowledge (Thomas & Thomas, 1994).

As one would expect, the research on this issue has shown that experts, as compared to novices, have a more complete and more highly differentiated knowledge base consisting of both declarative and procedural knowledge. (Abernethy et al., 1993, Abernethy et al., 1994; French & Thomas, 1987; Ste.Marie, 1998; Thomas & Thomas, 1994). For example, Abernethy et al. used a think-aloud task in examining breadth and depth of knowledge in snooker players. Using videotape of a snooker match, key points were chosen during which the tape was paused and a slide was shown. Context was also

provided in telling players the current score of the match. During the pause, participants verbalized what shot they would choose, what shots they would consider choosing, what shot options they would then reject, and finally what shots they would pre-plan.

Abernethy et al. revealed that expert players planned their shots further in advance than novices. Additionally, the finding that experts' forward planning was characterized by greater depth than that of novices was linked to a greater knowledge base on the part of the expert.

As mentioned, Ste-Marie (1998) used a method similar to that of Abernethy with gymnastic judges, moving the study of expertise from the perspective of the athlete to that of the judge. Although gymnastics can be classified as a closed skill sport with a stable environment, the task of the referee is similar to that of the judge in that the official is an external observer who makes judgments related to ongoing rapid actions. Viewing videotape of two to three lead in moves, judges were asked questions at a point when the screen was occluded. They were asked what possible gymnastics elements could be performed subsequent to those viewed, which of these elements they predicted would actually be performed, and what the common errors were which were associated with the predicted move. These questions were used to probe the judges' breadth of declarative knowledge.

The judges then viewed the video clip again, and this time, the tape footage included the gymnastics element they had attempted to anticipate. They were then asked to identify the error deductions for the performance of that gymnastics element as well as the name, symbol code and level of difficulty associated with the move. These questions

probed into the depth of the judges' declarative knowledge. The findings showed that expert gymnastics judges had greater depth and breadth of declarative knowledge base.

French and Thomas' (1987) examination of knowledge development in children's basketball is also relevant here. Their findings showed a significant relationship between basketball knowledge base and decision making performance. They concluded that decision making skill was a key difference between novice and expert children. The significance of this greater knowledge base was seen as an important component in anticipation as a decision making process. French and Thomas (1987) contended that anticipation cues were stored within the knowledge base. Reminiscent of Rasmussen's (1993) cue-task associations within rule-based behavior, French and Thomas (1987) described the use of productions, or "if-then" relationships, as valuable components in sport knowledge base:

The use of different cues in decision-making situations suggests that expert sport participants may be developing productions based upon stimulus-response pairs such as a given cue matched with an action. Although procedural knowledge in the form of productions has been used to model mental operations or processes, productions could easily be used to model physical actions as well (e.g., "if these conditions exist, then carry out this action or motor plan"). Thus, many of the cognitive decision-making processes involved in sport situations could be modeled by productions. (p. 17)

In the same manner that French and Thomas describe the importance of "if-then" productions, McLennan and Omodei (1996) also argued that knowledge of "if-then" pairings allowed for the active anticipatory simulations of possible play outcomes by referees. Further, they suggested that the pairings were developed as a function of experience through exposure to typical play sequences which arose in games. Thus, the



importance of experience in contributing to knowledge base development and subsequent decision making performance is once again reinforced.

To study whether the knowledge base differs between expert and novice rugby referees, referees will view videotapes and answer knowledge base questions. At the first tape stoppage, referees will be asked to give the possible play options at this point in the action, providing their breadth of knowledge. After choosing one of these options as the one likely to occur along with the referee decision for this action, they will be asked for justification by giving the information used in making this call. The information they have used will be a measure of depth of knowledge. Finally, depth of knowledge base will again be measured as the referees justify, for the second time, the decision they have made after viewing the entire play footage with the action they have attempted to anticipate.

#### Justification of Population of Study

A strong base of support has been provided in justifying the use of the expertise paradigm for examinations of naturalistic decision making. As well, the sport context has been argued to be a good medium for such an investigation. Indeed, Berieiter and Scardamalia (1993) chart the areas of application for cognitive expertise into domains such as computer programming, medical diagnosis and "...sports of all kinds" (p.ix). As mentioned, however, expertise research in sport has focused primarily on athletes and coaches. Another important participant that has not received much attention is the referee. This research seeks to redress this issue by investigating decision making processes via the expertise paradigm in the context of the rugby referee.

Recent events in the Leeds Rugby union can be used as illustration of the importance of referee's decision making. The referee of a game between Leeds and Rosslyn Park is said to have given the Leeds team an unfair advantage and the winning outcome. Erroneously, the law requiring uncontested scrums was invoked. Uncontested scrums dictate that there is no pushing between the two teams in the scrum, and the team putting the ball into the scrum will retain possession. It was felt that, as a result of the error of invoking this rule, the Leeds team lost the game, altering the league standings. In response to these events, Partridge (1998) concluded that it is "...about time referees were made professionals and disciplined accordingly for such blatant wrong decisions during matches the way players are evaluated" (www document, February 8, 1998, p. 4). This illustrates, then, that neither the demands nor the importance of the referee's role should be neglected.

Another feature specific to the game of rugby is the large number of "if-then" situations. The context of the play becomes very important, such that, passing the ball in one situation is legal, yet the same action in another context is illegal. For example, in a lineout, players from each team line up next to each other forming a tunnel. As the ball is thrown along the tunnel, jumpers from each team attempt to gain ball possession. The Laws dictate that a catch is legal if either both arms are raised, or, if only the inside arm closest to the opponents is raised. If, however, the ball is caught using only the outside arm and the inside arm is not raised, this is considered an infraction.

Despite these complex requirements, referees seem to perform these tasks quite well. Moreover, they make their decisions in a very rapid manner under pressured conditions. How do they do this? It would seem that tools such as anticipation and

knowledge base become essential in facilitating decision making. In the next discussion, I outline how these factors are expected to highlight the differences in expert and novice rugby referees, and thus elucidate their contributions to the decision making of referees.

### Hypotheses

Based on the literature, it is hypothesized that expert rugby referees will have greater depth and breadth of knowledge base than novices. If this is found, it will again demonstrate the importance of knowledge base for obtaining an expert advantage. It is similarly expected that experts will demonstrate superior anticipation than novices. Further, this anticipation is expected to contribute to the expert advantage in rugby referees. The hypotheses regarding how anticipation may affect decision making are more complex and need further development. Firstly, the situation where a referee correctly anticipates the stimulus and call will be presented. This will be followed by the hypotheses for when there was an incorrect anticipated stimulus.

It has been shown that prior experience with a stimulus facilitates its subsequent perceptual identification. This is illustrated by Jacoby and Dallas' (1981) study in which words were presented on a video screen and read aloud by subjects. In a test phase, participants were shown another word list, composed of words that had not been previously encountered as well as words that had been in the study phase. During the second stage, subjects were asked to identify words that were flashed for 50 ms. Results revealed a greater probability of correct identification of words which had been previously encountered, as contrasted with items presented for the first time. Subjects additionally perceived longer screen durations for those stimuli which they had previously encountered. The researchers concluded that there was a perceptual

enhancement towards the previously viewed items, which increased the ability to identify them despite such brief time exposures.

Jacoby and Dallas (1981) showed facilitation effects when an actual physical stimulus was involved. As referees anticipate the action which will take place, they create mental representations. It is believed, similar to McLennan and Omodei's logic (1996), that this anticipated stimulus will influence decision making in the same manner as when the actual stimulus is used. It is thus hypothesized that correct anticipation will result in faster decision making and increased accuracy as a function of the facilitation effects of a mental representation.

The expected outcome of incorrect anticipation will be discussed in light of research on memory-influenced biases found by Ste-Marie and colleagues (Ste-Marie & Lee, 1991; Ste-Marie & Valiquette, 1996). In their examination of gymnastics judges, Ste-Marie and Lee (1991) had the judges view videotapes of gymnastic elements at three different times of a three phase experiment. Of importance here were the first two phases, thus only these two will be discussed. During the study and perceptual test phases, judges viewed elements and were asked to identify form errors. The relationship of the items between these two phases was either that the element was the same with the same performance, the same element with a different performance (e.g., bent knees in study, straight knees in test) or a different element altogether, classified as new. The results showed that perceptual accuracy was affected by the relationship between the study and perceptual test phase presentations of an item. Judges' performance with elements from the same performance in both experimental phases had the highest accuracy, new elements were less accurate, and the least accurately judged elements were

those wherein test and perceptual phases were different. Prior exposure was concluded to have a biasing effect on judgment wherein an incongruence between the study and perceptual test phases decreased the accuracy of the performance judgments. That is, judges had a perceptual bias for the performance that was initially observed.

The research presented here questions whether these memory-influenced biases shown in the work of Ste-Marie and Lee (1991) and also proposed but untested in McLennan and Omodei (1996) would also exist in this setting of event anticipation in rugby. If it does, then the predictions become dependent upon the congruence between the anticipated stimulus and the actual stimulus as shown in the additional footage. Thus, an incorrect anticipated stimulus decision followed by incorrect actual stimulus decision will represent a congruent situation. This congruency is hypothesized to lead to fast, but inaccurate decision making. An incongruent situation in which incorrect anticipated stimulus decision is followed by correct actual stimulus decision is hypothesized to lead to a slowed decision speed but accurate decision making.

### Limitations

It is acknowledged that the present research proposal is limited by time and feasibility issues. Firstly, while it is acknowledged that an increase in the number of participants for the research is desirable, the 20 participants was considered appropriate for the time frame within which the research will take place. As far as the characteristics of the participants, limits arise from their experience within the field. Although Ericsson, Krampe, and Tesch-Romer (1993) contended that 10,000 hours of deliberate practice was required before attainment of expert status within a domain, it is unlikely that the expert group of rugby referees will have experienced this. To address this limitation, every

effort has been made to obtain participation from referees classified at the highest level by Rugby Canada. In this manner, it is hoped that more of a distinction will exist between the expert and novice participants.

The basic tenet of naturalistic decision making research is the study of “real world” decisions by “real people” in “real environments”. The tasks are time pressured, and influenced by a changeable environment, often providing only incomplete task information. Additionally, Orasanu and Connolly (1993) characterized these tasks as involving high stakes, such as a potential loss of life when a firefighter is forced to make a decision. While there is very rarely a threat of a loss of life in the decision making of rugby referees, there are definite stakes involved, especially in high profile international games. Additionally, Trudel, Dionne, and Bernard (1999) reported that the four factors affecting ice hockey referees were pressure from coaches and spectators, physiological strain, player-official relationships, and the belief that referees are not expected to call all infractions.

Considering these factors, the use of videotape in a laboratory setting is a drawback of the present design. Although efforts have been made to include these factors, such as providing the referees with the game score and the time remaining, the experimental nature of the design limits the capacity to do this. As well, referees will not be physically experiencing the demands of a game, nor will there be any interaction with the players or stakes involved. The video footage will, however, represent typical events likely to be encountered within the game.

**SECTION II**

Presentation of the Journal Article

The following article is entitled “*Making Sense of Chaos: Decision Making in High and Low Experience Rugby Referees*”. Selected measures from the initial study protocol are discussed here. The selected journal for submission is Perceptual and Motor Skills.



Running Head: Decision Making By Rugby Referees

Making Sense of Chaos: Decision Making By High and Low Experience Rugby Referees

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### Abstract

Decision making in referees was investigated through the use of the expertise paradigm. Twelve high and 12 low experience rugby referees made decisions concerning whether a call or no call was appropriate for 18 clips of rugby play. Responses were then assessed in terms of whether referees had detected an infraction in the rugby play (signal). As well, declarative and procedural knowledge were assessed through referees' discussion of information sources used in the decision making task. Results failed to show significant differences between the two groups in the signal detection analysis. The high experience group, however, did use significantly more sources of information than the low experience group in the process of making their decisions. The results are discussed in light of the present task, as well as the characteristics of information processing in this population.

In investigations of expertise and superior performance, one expert advantage has been shown to exist at the level of superior cognitive processing related to a specific domain. This has been evidenced in cognitive based tasks such as chess (Chase & Simon, 1973; deGroot, 1978;), physics (Newell & Simon, 1972) and bridge (Charness, 1979). Similar findings have since been found in various sports such as snooker (Abernethy, Neal, & Koning, 1994), field hockey (Starkes, 1987) and baseball (Paull & Glencross, 1997). Most of this sport expertise literature, however, has focused mainly on the athlete (e.g., Abernethy, Neal, & Konig, 1994; Starkes, Allard, Lindley, & O'Reilly, 1994) and the coach (e.g., Cote, Salmela, & Russel, 1995; Salmela, Draper, & Laplante, 1993), with little emphasis on other influential populations in sport. For instance, a population of limited study is that of the referee. Indeed, referees provide an excellent example of acquired skill in a domain which emphasizes the need for effective cognitive processing of events. A brief description of the responsibilities of a rugby football referee, which is the population of the present study, will thus be presented to highlight the task demands.

Rugby is a fast paced open skilled field sport played with 15 players a side. To the outside observer, a typical game appears to be a very chaotic event. The rugby referee, however, should be able to make sense of this chaos and to monitor the game play with effective decision making skills. Although there are two touch judges within the game, they play a limited role, and it is the referee who is considered the "...sole judge of fact and law..." (p. 124, IRFB Handbook, 1997). The referee is expected to apply the

laws of the game consistently and without variation. To do so, he<sup>1</sup> must monitor the actions of the 30 players who are often in very close proximity and concealing the ball. Difficulties for the referee may thus arise in determining when formations are legal and illegal, and in attempting to view misconduct while players obstruct sight lines.

In order to efficiently interpret and view actions, the referee must know where to look and how to use this information. This can often result in referees having to reposition themselves in order to achieve optimal angles. Further, the referee must constantly be aware of his position on the field to avoid obstructing the play. Keeping track of the score and the amount of time elapsed are also a referee's responsibility.

It is obvious from this discussion that a rugby referee must know a great deal in order to be an efficient decision maker. The referee must know the laws of the game, have an awareness of how particular plays develop, know where to look as a play is unfolding, and finally, referees must know where to position themselves. How significant is this refereeing knowledge? In addressing this question, it is important to note that an elaborate knowledge base has in fact been shown as a defining characteristic of experts (French, & Thomas, 1987; Russell, & Salmela, 1992; Ste-Marie, 1998; Thomas & Thomas, 1994). Knowledge is thus expected to be an important factor in rugby referee decision making. As such, one of the interests of this study was to investigate potential differences in knowledge base between low experience and high experience rugby referees.

Knowledge base has typically been described as consisting of three different types, these being declarative, procedural, and strategic knowledge (Magill, 1993). Of these, this study focused on declarative and procedural knowledge. Briefly, declarative

knowledge refers to the knowledge of rules and facts which pertain to the particular event, as well as knowing what action to perform at a given time. Declarative knowledge is thus shown when a person can declare information, such as what rule is important in a given situation. In contrast, procedural knowledge is “knowing how”, as shown in proficient performance of a skill. For the athlete, procedural knowledge is reflected in the athlete carrying out the selected response in action form. Further, declarative and procedural knowledge are distinct, in that one can know what to do but may not know how, or may know how to do something, but not be able to express it (Magill, 1993).

As an example of how declarative and procedural knowledge have been measured, McPherson and Thomas' (1989) study of the contributions of both types of knowledge in young novice and expert male tennis players is useful. A paper and pencil multiple choice test about rules, player positions, stroke production and scoring was used to determine declarative knowledge pertaining to tennis. Procedural knowledge was tested in drills as well as through coding videotape showing players in actual game performance.

Through this method, McPherson and Thomas (1989) compared information about what players knew should be done with information about the actions that they actually executed. Results showed that the experts declared the correct decision more often than novices, indicating greater declarative knowledge. These young experts were not, however, always able to perform the action they had chosen as the correct response. This highlights the distinction noted earlier between procedural and declarative knowledge.

Similar to measurements used with the athlete, a verbal or written measurement of declarative knowledge is argued here to be a useful tool in assessing the declarative knowledge of referees. When considering procedural knowledge, however, the measurement tool of observing a response may not be the only effective means of investigation. The reasoning behind this argument is that the decision making response of the referee is not always an action, as it is with the response of the athlete. A referee's procedural knowledge may also be expressed in terms of knowing where to look in order to facilitate viewing an infraction. In this sense then, procedural knowledge for refereeing could be referred to as knowing where as much as it is knowing how. For instance, evaluating whether referees know where to focus attention in assessing the legality of a tackle requires information related to where the referee is looking. Simply videotaping a referee, as McPherson and Thomas (1989) did with tennis players, may not indicate if he was focusing on the correct cues and thus "knew where" to look for information.

This analysis suggests the potential use of eye tracking equipment as a useful method for detecting the procedural knowledge of the referee. Another possibility, however, may be in soliciting from referees the sources of information used in making a decision to call or not call an infraction in a given play. Information concerning what was detected in the environment may thus be considered a measure of knowing where to look, and as such can be argued to measure procedural knowledge. For example, in response to the question: "What information did you use to decide on the action and the call?" a referee may offer that he looked at the flight path of the ball. The reporting of information used to make a decision, then, allows some investigation into procedural

knowledge. It is acknowledged, however, that this conscious, overt use of information will not tap into the type of procedural knowledge that may be used by a referee without his ability to express it.

Not only have experts revealed a more significant knowledge base than novices, they consistently show better performance in component tasks required for performance within their given sport. For instance, Paull and Glencross (1997) used a ball pitch display to show experts' superior ability in predicting where a ball will pass through a strike zone. Similarly, Allard and Starkes (1980) reported that volleyball players were able to detect the presence of a volleyball much faster than non-players. These advantages shown on component skills are argued to transfer to performance of the sport itself. Such advantages have also been shown in a population more similar to referees, that of gymnastics judges. Comparing novice and expert gymnastics judges, Ste-Marie and Lee (1991) reported that expert gymnastics judges were better at detecting form errors than novice judges. Given these findings, we also tested whether high and low experience rugby referee's performance in detecting infractions.

In sum, the two main points of interest here concerned investigating differences between high and low experience referees with respect to knowledge base and the detection of infractions. It was expected that the amount of information used would be greater for the high experience than the low experience referees, reflecting a more elaborate knowledge base. It was also hypothesized that the high experience referees would reveal superiority in detecting infractions as compared to low experience referees.

## Method

### Participants

A total of 24 rugby referees were recruited from the Ottawa and Montreal regions to participate in this study. Following guidelines presented by Ericsson and colleagues (1993, 1994, 1996), inclusion criteria for the high experience participants ( $M=16.08$  years, range = 10-41) was that they had refereed for 10 years or more.<sup>2</sup> The low experience group ( $M=3.75$  years, range = 2-5) had accumulated five years or less of refereeing experience. Recruitment of referees was done through telephone contact from phone lists provided by the Eastern Ontario Rugby Union as well as the Quebec Rugby Federation. All participants provided informed consent prior to study.

### Materials

Twenty-four videotaped sequences of rugby plays were constructed and placed on a single videotape. Eighteen of these were used for test stimuli, and the remaining six clips consisted of one example and five lead in clips in order to familiarize the participants with the procedure. The tapes included audio tones to indicate an upcoming clip. Each videotape sequence consisted of a freeze frame of the rugby play, followed by two clips of the same game footage that ran for approximately eight to 12 seconds' duration. The 18 sequences of game footage used represented different aspects of the game in which infringements might occur. Specifically, six tackle plays, six kick plays, and six lineout plays.

The videotape was created from game footage obtained from men's and women's games during the 1998 Ottawa/Quebec summer season. For this footage, a researcher filmed games from a position along the touchline (sideline). This accounted for 80 % of



the materials. The remaining 20 % was created through “staging” actions with the Ottawa Irish Women’s rugby team during practices of the same season. For those sequences, the team was divided into two groups, each wearing a different set of jerseys. The players then performed various rugby plays.

Half of the video rugby plays contained an infraction (signal), and half did not (noise). The existence or absence of an infraction was confirmed and agreed upon by two exterior expert raters, each having over 15 years of experience, and each having refereed in representative matches involving players at the provincial level or higher. Each external rater was sent a videotape with 32 rugby play sequences and a set of instructions (see Appendix E). These expert raters were free to rewind, replay and use slow motion in viewing the clips in order to feel confident with their ratings.

This preview of the 32 clips resulted in the 18 clips that were used as test stimuli. Five items were chosen from the ones remaining to be the lead in items. All three play types of kicks, lineouts, and tackles were represented in the first five lead-ins. An additional example clip was chosen for use in the opening explanation of the task and familiarization with the procedure for the participants. For purposes of data collection, an audio recorder was used to record the oral information provided by the referees.

### Procedure

Participants first completed an information sheet related to their refereeing and playing experience. Referees were then seated approximately one meter away from the television unit and were read instructions by the researcher. Following this, referees were stepped through the example test item which involved watching a video sequence while

the experimenter provided an example of appropriate responses to the questions posed throughout the different phases of the study.

The five lead in items were then presented to familiarize the participants with the process. At this time, the researcher answered any questions until the participant became accustomed to the procedure, as well as the timing and structure of the videotape. Following this, the researcher began audiotaping the oral responses given for the subsequent 18 test items.

For data collection, referees viewed 18 sequences of videotaped rugby play as signal detection items. Half of the test items had an infraction (signal) and half did not (noise). Each test item was composed of three phases. The first phase consisted of a freeze frame. The freeze frame was used for referees to orient themselves to the upcoming action. The second video phase showed five to six seconds of rugby play footage, and then the screen went blank. It was obvious at this point what action would follow, but not what variation on this action would be shown. The image was occluded, for example, as a player's foot was raised toward a ball he held in his hand. This made the fact that the next action would be a kick obvious. It was not obvious, however, whether the ball would be kicked out of bounds or up field in bounds. Referees were then asked if they felt there would be an infraction in the ensuing action, and how they had made this decision. This was done using the following questions: "What would your call for this be?" and "What information did you use to determine the action and the call?"

Once referees finished responding to these questions, the third phase of the test item was shown. In this final section of the test item, the latter portion of the second phase was repeated, along with additional footage including the event of focus for

infraction detection. At this point, referees were instructed to identify the action and any associated calls for the footage that they viewed. If the participant felt there was no infraction, they then made a call of “play on” or “no call”. In addition, participants were probed with the following question: “ In identifying the action and the call, did you use information in addition to what you said before?”.

Participants were tested individually and the study was paced based on their responses. This resulted in testing sessions lasting from 45 minutes to 2 hours in duration. The researcher remained with referees throughout the entire study to pause the video during intervals and to pose the questions. Participants were not informed of whether their responses were “correct” or “incorrect”.

### Analysis

#### Signal Detection

Responses made in the third portion of each video clip were used for the signal detection analysis. Using these responses, inferences were made as to whether the target infraction was detected or not. One of four designations was then applied for responses, based on signal detection theory (Macmillan & Creelman, 1991). When an infraction was present and it was detected, this was labeled a “hit”. It is worth noting, too, that infractions were often detected, but no call was made, resulting in both “hit, no call” and “hit call” designations. These responses were both included in the hit rate, as the signal, of course, was detected. A “miss” occurred when an infraction was present and the referee failed to detect it. A “false alarm” occurred when a referee reported an infraction when the clip actually had no infraction present. Finally, a “correct rejection” designated

a referee correctly stating that no infraction was present in the clip when this in fact was the case.

### Sources of Information.

An inductive approach was used in creating the coding categories for the information sources used by referees. In this manner, the audiotapes from the first four participants were listened to and transcribed. Common thematic codes were generated for quantification purposes. Transcription and code creation was repeated until saturation was met. Interrater reliability was then used for definitional clarity, whereby a second rater underwent a training period. During this process, the raters refined definitions of codes, and distinguished between information which was task related, and that which was not task related (i.e., comments made that were not related to making the decision for the rugby test item). Interrater agreement for these codes was above 80 %, which is considered an acceptable rate of check-coding agreement (Miles & Huberman, 1994).

Using the 22 codes, one item of information was then counted under only one code. For example, statements related to the position of the players were placed in one code, and statements about the ball location, or ball path were placed in another (see Appendix F). Subsequent to this, 17 of the 22 codes were grouped into four clusters.

A deductive process, relying on concepts within the knowledge literature, was used to create the four clusters. In addressing declarative knowledge, information provided about the decision that reflected issues related to the rules of the game, or other factual knowledge built up from semantic and episodic memory was measured. In fact, within the measure of declarative knowledge, semantic and episodic memory were

additionally used as two different clusters. This corresponds with theorizing that episodic and semantic memory build onto declarative knowledge (Magill, 1993).

The integration of semantic memory within declarative knowledge is described as a store of factual and conceptual information. It is said to represent conditions of the situation which do not have a perceptual link (Tulving, 1985). For example, remembering the information that a penalty kick is awarded for a dangerous tackle in rugby is an example of semantic memory. Thus, information given by a referee that referred to a law of the game, or positions of players with respect to lines on the field was coded within the “declarative semantic” cluster.

In contrast, episodic memory is stored information related to events or episodes that have been personally experienced, and thus have temporal and spatial properties (Tulving & Thomson, 1973). For example, a referee may possess information that the team he is refereeing is not competent at kicking as a function of the specific experiences he has had with this set of players on previous occasions. Similarly, a personal experience with a player was regarded as episodic information. Thus, the statement “I know this player, and I base my decision on the fact that he’s a good player.” would be regarded as a statement within the “declarative episodic” cluster.

The cluster of “procedural seen” was used to classify items the referees had seen and used in making decisions. This cluster is exemplified by the statement, “I could see the lines marked on the field, and I used those”. Interestingly, a cluster was also created as a function of the study taking place in a laboratory setting with referees “performing” from a stationary position. This situation often resulted in the referees indicating that important pieces of information which they felt they needed or could have used were

lacking. To capture these occurrences, the cluster of “procedural not seen” was created. This cluster contained items the referees had not seen, but would have liked to see in the process of making their decisions. An example is the comment, “I would have used the field markings, but I couldn’t see them in this clip”. In sum, information statements from referees that revealed where they looked and where they would have looked, if given the opportunity, were used to measure procedural knowledge.

There were five codes remaining which were not placed in these four clusters. These consisted of 1) referee reports of the use of the videotape game referee as a source of decision making information, as when a participant has seen the game referee begin to raise his arm, indicating an upcoming infraction call, (“actions of referee”), 2) the use of “preventive refereeing” and verbal warnings to players, exemplified when a referee has detected an infraction but decided not to call it, opting to warn a player instead (“verbal”), 3) detected infractions other than the target or signal infraction, such as the detection of an illegal tackle in a clip where the lineout is the main focus (“other infraction”), 4) the use of a personal “refereeing philosophy” in decision making, such as a hesitation to call what may be interpreted as an unimportant infraction and a preference for maintaining the “game flow” and letting the players play (“refereeing philosophy”), and 5) any information which could not otherwise be classified (“other”). These codes, however, were felt to be peripheral in nature, and did not fit into the knowledge base framework of interest. They are thus presented here mainly for an informative purpose and will not be analyzed.

The analysis was thus performed with the factors of procedural knowledge (not seen, seen), and declarative knowledge (semantic, episodic). Coding and subsequent

cluster placements occurred simultaneously with data collection, and reliability was tested through intrarater checks. Intrarater reliability was ensured at three different points during the coding process. In the first two weeks of coding, a randomly selected portion of test items was coded from the data of three different participants. These items were re-coded three weeks later, and then again five weeks later.

At each of the reliability checking points, agreement with previous coding was consistently above the minimum standard of 80%. Specifically, the reliability was checked for each cluster used in the analysis. In the declarative knowledge clusters, the episodic cluster of codes was determined to have an overall reliability of 87.3%, and the semantic cluster of 89.4%. The cluster of “procedural seen” had an average reliability of 90.7%, and the “procedural not seen” cluster of 87.5%. These four reliabilities resulted in the clusters demonstrating a coding reliability of 88.7%. Averaging the results from the three different checking points, the overall reliability score of all of the codes and all of the clusters put together was 86.6%. In using the standards presented by Miles and Huberman (1994), these coding reliabilities are acceptable.

## Results

### Signal Detection

Hit rates and false alarm rates were calculated for the high experience and low experience groups. No significant differences were found. Both groups had the same hit rate (53.7%), and false alarm rates were also similar (high experience = 6.4%, low experience = 7.4%). Hence, no sensitivity or response bias differences were evident either.

### Information Sources

The sum scores of the clusters were entered into a 2 X 2 X 2 (Group, Declarative, Procedural) analysis of variance. This analysis revealed a main effect of Group  $F(1,22) = 4.09$ ,  $p = .055$ , whereby high experience referees provided more information across all four clusters ( $M = 26.10$ ) as compared with low experience referees ( $M = 19.44$ ). The analysis also revealed a main effect of Knowledge Type,  $F(1, 22) = 281.29$ ,  $p < .01$ . All referees provided a greater number of information sources from the procedural clusters ( $M = 38.90$ ) than from the declarative clusters ( $M = 6.65$ ). (Refer to Appendix F for example quotation items from the clusters.) As well, no significant interactions were obtained (refer to Table 1).

### Discussion

Two measures were used to investigate differences between high and low experience referees. A signal detection task was used to investigate detection of infractions, and referee reports were used to measure information sources in decision making. The results of the signal detection task yielded no significant differences between the two groups. This is contradictory to other research that has shown detection differences (e.g., Ste-Marie & Lee, 1991). The question arises as to why the high and low experience groups performed similarly. We propose two explanations. The first of these is related to the sample population, and the second to the nature of the laboratory situation used.

In regards to the sample population, a certain lack of distinction existed between the high and low experience groups. This was a result of the small population of rugby referees in the area, which limited access and necessitated a widening of criteria for study



inclusion. The high experience referees had thus refereed for 10 years or more, and the low experience group for five years or less. A greater distinction between the two groups would have been ideal, however, the limited starting population size did not allow for this.

In terms of the laboratory task used for this investigation, previous literature has shown that the further away a study task is from the domain of expertise, the less likely an expert advantage will be exhibited (e.g., Abernethy, Neal & Koning, 1994; Bard, Fleury & Goulet, 1994; Ripoll, Kerlirzin, Stein & Rein, 1995). Replication of task demands is therefore important for obtaining expert-novice differences. The laboratory task in this study, however, was limited on this dimension. Specifically, the rugby actions on tape were recorded from a perspective along the touchline (sideline) from the point of view of a player or coach, and not that of the referee. As such, the content in the videotaped segments of play were likely different from that which would be experienced by a referee in a typical game. An additional limit along this same line was that, by responding to video sequences, referees were exposed to information from only one viewpoint. Typically, however, referees change their position, adjusting their angle of view of events that are unfolding. Hence, decision making in response to videotaped sequences placed the participants in a stationary position, when they would otherwise be dynamic. Finally, the video clips presented sequences in isolation from the rest of the game, limiting a referee's experience of the ongoing game context. Further, it is argued that, in comparison to the low experience referee, high experience referees benefit more from their use of the aforementioned real features of the task. Hence, lacking the opportunity to use the cognitive strategies which mediate their expertise, high experience

referees performed similarly to the low experience group. Given this result, a more naturalistic task may have otherwise revealed an advantage of high experience over low experience referees.

The analysis of the data on information sources lends support to this lack of task naturalism explanation for the signal detection results. The cluster labeled “procedural not seen”, is particularly important here. For statements scored in this cluster, referees referred to information that they felt was missing from the videotape sequences. For example, referees often stated that they would have positioned themselves differently to improve their point of view. The following quotation illustrates this point: “I was, as a referee, extremely poorly positioned, because I was not in any position to assess a forward pass. I was bad on this one. I was probably lazy and waiting for something else (laughs).” (Participant RH7CF1). Also included in this cluster were statements related to the feeling that a broader scope of view was needed. For example, one referee commented, “It’s hard to say when you’re looking at a screen. I was looking for the five metre line, and I couldn’t see it. I would have liked to see the five metre line.” (Participant RH6CF2).

As previously mentioned, positioning is extremely important to the rugby referee’s task, and provides the opportunity to look at the necessary information in the appropriate manner. It is thus notable that the number of items in the “procedural not seen” cluster was significantly greater for the high experience referees than the low experience referees. Thus, when referees were given the opportunity to express features related to their processing, (such as a particular point of view) the expert advantage was revealed. Such findings support the possibility that the laboratory task did not allow high

experience referees to perform the way they normally do, and that this resulted in an elimination of the expert advantage on the signal detection task.

Despite the fact that there were no differences found in the detection task, differences were revealed at the knowledge base level. Specifically, a greater use of information demonstrated a superior procedural knowledge base on the part of the high experience referees. As mentioned, high experience referees also felt a greater lacking of potentially useful information. Taken together, this is indicative that the more experienced referees are more skilled in knowing where to look as compared to the low experience referees.

Differences in information sources also showed high experience referees' larger declarative knowledge base for both semantic and episodic components. This indicates that high experience referees referred more to their knowledge about the laws of the game and their applications. Also of interest here was the finding that all referees reported more information in the semantic cluster of declarative knowledge when compared to the episodic cluster. These findings can also be explained in relationship to the limits of the task. That is, because individual play sequences were extracted from games, there was little opportunity to create episodic associations with the stimuli. The actions being presented had little spatial and temporal cues from the rest of the games from which they had been drawn. By showing these isolated actions, there was no access to a "game history". Further, episodic memory can be described as functioning both with awareness and without awareness, such that a referee may be unaware when a given decision is based on past experience or knowledge (e.g., Jacoby & Witherspoon, 1982). If, in fact,

this process occurs at an unaware level, this lack of awareness may preclude a referee reporting the use of episodic information in decision making.

Regardless of these limitations, there were still information items scored in the “declarative episodic” cluster. An example is the following statement made by a referee: “I know this player--I’ve coached him. I think the kick will be fine because he’s a pretty skilled player.” (Participant RHC8F2). Such a statement does, however, bring up the issue of whether such “top-down” processing should enter into a referee’s decision making. One might say that, in theory, all sport monitors are expected to be objective, external decision makers. In practice, however, studies show that, in fact, decisions are frequently influenced by past experiences or present context (e.g., Trudel, Dionne, & Bernard, 1999). For instance, one referee in this study offered that “...usually, if you know the teams, you know if the ball is going to be well-taken or not.” (Participant RH6CF2).

This study relied on the quantitative level for analysis. On a qualitative level, researchers using verbal protocol data have noted that experts report more complex knowledge representations than novices. For example, McPherson and Thomas (1989) found that young expert tennis players access more complex concepts in a tennis problem solving situation than novices. They additionally found the expert group to reveal greater connections between these concepts. This discussion presents the idea that analyzing the complexity of information sources from the verbal reports of the two groups in this study may reveal interesting findings. In fact, a preliminary comparison of the data seemed to show that, while both groups discussed tactical and strategic reasons for the plays that they viewed, as well as options available to the players, the high experience referees did

this more often. More importantly, the high experience group seemed to use this type of reasoning to infer missing information. For example, one referee discussed what was likely to occur given the footage that he had viewed, thus inferring the field position of the players. He then based his decision on this information.

This looks like an intentional up and under kick. It looks like the forwards will go through, try to gather the ball and, as a pack, try to force their way over the line. I'm presuming, then, that they're fairly close to the line at this stage, close to the 22 metre line. (Participant RH9F2).

This discussion reveals a complex analysis of the situation resulting from links between information sources. It is proposed that such comparisons between expert and novice referees would be an interesting feature for future research.

In sum, this study represented work in the sport expertise area with a novel population; that of the referee. Using this new population brought to light special considerations. One such consideration was the concept of referees' "knowing where" as a measure of procedural knowledge. This concept thus prompted the measurement of procedural knowledge through the use of oral reports related to information being used in decision making. This is similar to the method used by French et al. (1996) in their examination of the knowledge development of youth baseball players. In that study, content analysis of athletes' expressed thoughts during a problem solving task was described as an opportunity for more thorough descriptions of sport knowledge development. This study builds on this recommendation and extends it to the knowledge used by rugby referees in decision making.

A further note of consideration is our use of episodic and semantic memory stores. To our knowledge, very little research incorporating knowledge base has thus far placed a

similar emphasis on these structures. This discussion of semantic and episodic memory then provided links to the type of information processing being used and to a more clearly defined declarative knowledge base. Finally, a recommendation that surfaces from this research is that efforts to understand how referees operate in the “real world” must be approached by methods that better reflect the actual task demands.

## References

- Abernethy, B., Neal, R. J., & Koning, P. (1994). Visual-perceptual and cognitive differences between expert, intermediate, and novice snooker players. Applied Cognitive Psychology, 8, 185-211.
- Allard, F. & Starkes, J. L. (1980). Perception in sport: Volleyball. Journal of Sport Psychology, 2, 22-33.
- Charness, N. (1979). Components of skill in bridge. Canadian Journal of Psychology, 33, 1-16.
- Chase, W. G. & Simon, H. A. (1973). The mind's eye in chess. In W. G. Chase (Ed.), Visual information processing. (pp. 215-281). New York: Academic Press..
- Cote, J., Salmela, J.H., & Russell, S. (1995). The knowledge of high-performance gymnastic coaches: Competition and training considerations. The Sport Psychologist, 9, 65-75.
- deGroot, A. (1978). Thought and choice in chess. The Hague: Mouton.
- Ericsson, K. A. (1996) The acquisition of expert performance in the road to excellence. In K. A. Ericsson (Ed.), The acquisition of expert performance in the arts and the sciences, and sports, and games. (pp. 1-49). Mahwah, NJ: Lawrence Erlbaum and Associates.
- Ericsson, K. A., & Charness, N. (1994). Expert performance: Its structure and acquisition. American Psychologist, 49 (8), 725-747.
- Ericsson, K. A., Krampe, R. T., & Tesch-Romer, C. (1993). The role of deliberate practice in the acquisition of expert performance. Psychological Review, 100, 363-406.

French, K. E., Nevett, M. E., Spurgeon, J. H., Graham, K. C., Rink, J. E., & McPherson, S. L. (1996). Knowledge representation and problem solution in expert and novice youth baseball players. Research Quarterly for Exercise and Sport, *67* (4), 386-395.

French, K. E., & Thomas, J. R. (1987). The relation of knowledge development to children's basketball performance. Journal of Sport Psychology, *9*, 15-32.

International Rugby Football Board, (1997). Handbook, 1997. (Handbook).

Jacoby, L. L. (1983). Remembering the data: Analyzing interactive processes in reading. Journal of Verbal Learning and Verbal Behavior, *22*, 485-508.

Jacoby, L. L., & Witherspoon, D. (1982). Remembering without awareness. Canadian Journal of Psychology, *36*(2), 300-324.

Magill, R. A. (1993). Motor learning: Concepts and applications (5th Edition). Louisiana State University: Brown & Benchmark.

Macmillan, N. A., & Creelman, C. D. (1991). Detection theory: A user's guide. Melbourne Aus.: Cambridge.

McPherson, S. L., & Thomas, J. R. (1989). Relation of knowledge and performance in boys' tennis: Age and expertise. Journal of Experimental Child Psychology, *48*, 190-211.

Miles, M. B., & Huberman, A. M. (1994). Qualitative data analysis (2<sup>nd</sup> ed.). Thousand Oaks, CA: Sage.

Newell, A., & Simon, H. A. (1972). Human problem solving. Englewood Cliffs, NJ: Prentice-Hall.



Paull, G. C., & Glencross, D. J. (1997). Expert perception and decision making in baseball. International Journal of Sport Psychology, 28, 35-56.

Russell, S. J., & Salmela, J. H. (1992). Quantifying expert athlete knowledge. Journal of Applied Sport Psychology, 4, 10-26.

Salmela, J.H., Draper, S. & LaPlante, D., (1993). Development of expert coaches of team sports. In S. Serpa, J. Alves, V. Ferreira, & A. Paul-Brito (Eds.) Sport psychology: An integrated approach, (pp. 296-300). Lisbon, FMH.

Starkes, J. L. (1987). Skill in field hockey: The nature of the cognitive advantage. Journal of Sport Psychology, 9, 146-160.

Starkes, J., Allard, F., Lindley, S., & O'Reilly, K. (1994). Abilities and skill in basketball. International Journal of Sport Psychology, 35, 249-265.

Ste-Marie, D.M., & Lee, T. D. (1991). Prior processing effects on gymnastics judging. Journal of Experimental Psychology: Learning, Memory, and Cognition, 17, 126-136.

Ste-Marie, D. M., & Valiquette, S.M. (1996). Enduring memory-influences biases in gymnastics judging. Journal of Experimental Psychology: Learning, Memory and Cognition, 22 (6), 1498-1502.

Ste-Marie, D. M. (1998). Expert-novice differences in gymnastics judging. Journal of Applied Cognitive Psychology, (In press).

Thomas, K. T., & Thomas, J. R. (1994). Developing expertise in sport: The relation of knowledge and performance. International Journal of Sport Psychology, 25, 295-312.

Trudel, P., Dionne, J.-P., & Bernard, D. Differences between assessments of penalties in ice hockey referees, coaches, players, and parents. In A. B. Ashare, (Ed.) Safety in ice hockey: Third Volume.(In press).

Tulving, E. (1985). How many memory systems are there? American Psychologist, 40, 385-398.

Tulving, E., & Thompson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. Psychological Review, 80, 352-373.

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### Footnotes

1. The vast majority of rugby referees in the area are male, and this is reflected in the study sample's strong majority of male participants. Referees will thus be referred to using the masculine pronoun throughout the document for ease of language.

2. Although attempts were made to follow these guidelines, the limited population from which the sample was drawn required loosening of criteria such that factors such as deliberate practice, performance levels, and the number of games refereed per year were not controlled for participant inclusion.

Table 1.: Mean Scores on Information Clusters (number of items per cluster)

	Procedural			Declarative		
	Not Seen	Seen		Episodic	Semantic	
	sd	mean	sd	mean	sd	mean
High Experience	15.67	15.83	20.68	72.75	4.52	6.33
Low Experience	5.38	9.25	18.50	57.75	4.36	4.42
Entire Sample	11.94	12.54	20.67	65.25	4.45	5.375
						5.52
						7.92

**SECTION III**

## Elaborated Results

In addition to statistical analyses included in the article, analyses of the remaining five information codes were performed. In the code “actions of referee” indicating the use of the video referee as a source of information, and “verbal” indicating a verbal warning to players in lieu of a blown whistle, no significant differences existed between the high and low experience referee groups. This was also the case for the “refereeing philosophy” code. This code was used to label information provided by referees which discussed their personal philosophy and interpretation of laws. For example, the desire to permit the athletes to play as much as possible and thus the reluctance to unnecessarily interrupt the flow of the game may prompt a referee to decline calling a penalty. This is shown in the following comment:

It’s hard to see whether the ball was physically moved through the mark, but, personally, kicking the ball one centimetre through the mark or tapping it through your hands, I don’t think has a bearing on the game of rugby if you’re trying to play open air. I know other refs would probably call that... (Participant RL4F2)

The “other infraction” code was used when a referee detected an infraction other than the target infraction the expert raters had agreed upon. This was distinguished from a false alarm in that the “other infraction” action was not the focus of the clip. For example, in a clip with a legal tackle as the intended focus, identification of a legal tackle followed by the identification of an illegal “ball knocked forward” was coded as an “other infraction” item. On an “other infraction”, then, the referee is picking up additional information from the footage, subsequent to focusing on the intended action. In analysis

of the total number of “other infractions” for each group, there were no significant differences between the high and low experience referees.

The final code not included in the article analysis was that for “other”. Items coded in this category did not fit into any of the other established codes. A one way analysis of variance of the number of items in this code showed a significant difference between the two groups,  $F(1,22) = 4.65$ ,  $p = .042$  with high experience referees ( $M = 7.42$ ) offering more of this type of item than low experience referees ( $M = 2.42$ ). This greater number of “other” statements provides support to the article finding that the high experience group extracted more information across all of the four knowledge clusters. That is, no matter what the category of information, or even if the item does not fit into a category, the high experience referee will extract more information while making decisions.

Further, high experience referees providing more “other” items is indicative of a more elaborated and differentiated knowledge base as compared to the low experience group. In information sources for decision making, then, items that are unusual and do not fit with the “standard” classifications will more likely be coming from the high experience referee rather than the low experience one. Perhaps this indicates a difference between an advanced knowledge as contrasted with a standard knowledge of where to draw information from. As demonstrated, then, although the difference in the “other” category provides interesting points for discussion, the exclusion of this analysis from the article is due to its peripheral nature to the issues discussed pertaining to knowledge structures.



## Elaborated Discussion

### Summary of Measures Dropped

The original research design of this study incorporated measures for anticipation, voice reaction time, and breadth of knowledge base in addition to the measures already discussed in the article (signal detection and information sources contributing to knowledge base). Certain issues arose, however, as the data collection and analysis unfolded. These issues led to many of the measures being excluded from the experimental design. This section will discuss the preliminary results using those measures and the reasoning behind their exclusion from the final analysis. The issues in this section also led to considerations regarding the responsibilities and task requirements of various sport monitors. These considerations resulted in the inclusion of a section comprised of these thoughts.

Anticipation. The method used in this study originally incorporated measures of anticipation. During the first phase of the video clip, referees were asked to anticipate the upcoming action, as well as the referee call for that action. Originally it was thought that a referee might respond: "I think that the ball is not going to be thrown straight, and therefore the call will be scrum or line again for the other team". Referees, however, were exceedingly reluctant to anticipate a call, and would often give more than one possibility for what was likely to happen. Even when the researcher prompted them to make a choice, many participants responded with "if-then" statements, stating that if in fact there were to be an infraction, it would be called, but if not, then it would be a "play on" situation. Asked, then if they thought it would be one or the other, participants would

often decline to make a choice without seeing other details of the game. This feeling that other information was missing will be returned to later.

Although the reluctance to anticipate led to the inability to measure anticipation as expected, it provided support for a link between procedural knowledge and physical actions. That is, these “if-then” responses support French and Thomas’ (1987) suggestion that sport decision making may be exemplified by the thought “if these conditions exist, then carry out this action or motor plan”. (p. 17). Further, the reluctance to anticipate the upcoming action and call is postulated to be a product of the laws of the game, particularly the advantage law. This law states:

The referee shall not whistle for an infringement during play which is followed by an advantage gained by the non-offending team. An advantage must be either territorial or such possession of the ball as constitutes an obvious tactical advantage. A mere opportunity to gain advantage is not sufficient. (p. 134, IRFB Handbook, 1997)

Referees, therefore, do not blow the whistle immediately following an infraction, but wait to see if the other team has gained an advantage. One participant illustrates how this impacted on decision making in the following quotation. When the researcher tried to prompt the referee into choosing what action and call would follow, the response was:

I would never make a call at this point. The only time I would make a call at this point is if there was a dangerous play from a late hit. Then the ball would still be in the air, and the whistle would be blown. Otherwise, it could be that there is no one at the reception of the ball, a person from the kicking (non-offending team) takes the ball and scores a beautiful try under the posts. You wouldn’t want me to blow that up because otherwise I would have the coach and 15 other players screaming at me “what have you done?”

(Participant RH7CF1)

Similar comments were made throughout, indicating that the influence of the advantage law prompted referees to wait and perhaps discouraged anticipation of actions and their immediate outcome. Due to this, the referees were not truly performing the task of anticipating the action and call, prompting this measure to be dropped. The difficulty encountered with the task was, however, an interesting finding.

Voice reaction time. A voice reaction timer was used in the second phase of each clip. The referees were instructed at this phase to identify the action as quickly as possible. A timer was triggered by an audio tone inserted at the action, and was stopped when the participants spoke into the microphone attached to the headpiece. It was hypothesized that high experience referees would identify actions more quickly than the low experience referees.

As the study progressed, however, it was clear that this was a difficult task for the referees. Participants were observed to wait for the end of the action, and often contemplate further before responding. This extended delay frequently resulted in no voice reaction time being recorded as the timer was set with a timeout period of 12 seconds. Additionally, it was noted that the difficulty to make a quick response seemed greater for the high experience referees. In fact, in an early analysis of the data, the mean reaction time of the high experience referees (N=4) was 1.73 seconds, as compared to the faster mean of the low experience referees (N=3) of 1.30 seconds.

It was thus found that the high experience referees had slower reaction times than the low experience referees. Again, the advantage law is thought to have played a part in these findings. It is important to note that all of the referees were told to disregard the advantage law. Basically, reporting as quickly as possible was a message to disregard

advantage. Given this, and taking into consideration that high experience referees have accumulated more years using the advantage law than novices, the following argument is presented. First, although the low experience referees had difficulty acting against the advantage law and responding quickly, it was easier for this group to disregard advantage because it was not as “ingrained”, resulting in faster reaction times. For high experience referees, however, the advantage law is more ingrained, and they could not break the habit and respond quickly, resulting in slower voice reaction times. Thus, waiting for the play to develop, and the resultant response latency was a product of experience using the advantage law.

Once again, as a result of the task not being performed accordingly, the voice reaction time measure was subsequently dropped. The attempt to use this measure, however, did provide some interesting insights into how rugby referees function. Additionally, difficulty with this task became a point of note in considering the population of sport monitors as a whole, and is introduced later in discussion of the varying roles of sport monitors.

Breadth of Knowledge Base. As mentioned, at the first phase of each video clip, referees were asked to anticipate what action would follow. They were also asked what other possible things might happen at this point. It was hypothesized that this measure would reveal high experience referees to have a greater breadth of knowledge base than the low experience participants. The measure that was used to determine this was the number of possibilities stated by the referee.

Although it seemed a feasible measure, some referees, particularly the high experience group, used information present within the clips to arrive at fewer

possibilities. For example, a referee may say that, given the score and time remaining, and based on knowledge of the team and the player's body position, only two possible things could happen. High experience referees, then, sometimes limited the number of possibilities based on their knowledge of the game. Low experience referees, however, sometimes overlooked these other factors considered by the high experience referees and gave more possibilities. As such, the logic that a referee offering fewer possibilities revealed a narrower knowledge base was thought to be erroneous.

Additional difficulty lay in the imprecise nature of measuring responses regarding when the possible actions mentioned would occur temporally. That is, one referee may state that the player could kick the ball down the field, run forward, retrieve the ball and be tackled out of bounds. A second referee may just offer the possibility of the player kicking the ball down the field. Can these two responses be considered the same or should one be counted as revealing a greater knowledge base? The instructions unfortunately did not specify how many actions after the clip the referees should discuss. As such, it would have been very difficult to control this aspect of the data measure.

Finally, in some situations the vast number of possibilities became a problem. One referee stated: "1000 things can happen. I could give you a lecture for a half an hour." (Participant RH7CF1). Although aware that "thousands" of things might happen, referees often chose to list actions that were *most likely* to occur, whereas others mentioned possibilities less likely to occur as well. This again was not touched upon in the instructions, and some referees became more imaginative, as it were, than others. For example, several referees mentioned the possibility of a dog running onto the field, which is a possibility and must be counted as such, but when another referee excludes this

statement, it does not seem correct to conclude that the second referee has a smaller knowledge base. This fact increased the “subjective” component on the part of the researcher, such that an evaluation of certain statements would have been needed to determine if they should be included or not as an item. This evaluative process was considered too difficult for inclusion in the study. Thus, for these reasons and difficulties, this measure of knowledge base was not included in the article analysis.

#### Further Observations about the Rugby Referee

The previous section discussed the measures that were excluded from the study due to the difficulties encountered. These difficulties often resulted in insights into the task demands and consequent functioning of the rugby referee. Further observations were also made which again helped to formulate a more complete understanding of the rugby referee’s functioning within a game. These observations and insights will be presented in this section.

Although it was acknowledged that the laboratory context of this study limited many “real life” task features, it was not anticipated that this would create as much difficulty as it did. In fact, referees expressed time and again how difficult it was for them to evaluate actions occurring in isolation from the rest of the game. They referred to how their decisions were typically influenced by how the game had been proceeding. For example, one referee stated: “I look at that early in the game, and if there’s any indication of cheating and movement I call it right away, and that way I don’t have that problem for the rest of the game.” (Participant RC4LF1). The point of the game at which an infraction occurs is therefore important to this particular referee. It was not, however, just the game time and the game score which affected decisions, but rather the stage and

tone of the game as well, as another referee commented: “The given score and time is irrelevant to me. It doesn’t matter to me, although, early on in the game, there are certain things, for example, setting the tone. Players push to see how far they can get.”

(KR3LFR1). Another referee highlighted the need to see the whole game in stating, “I should be using information from the rest of the game; what’s been happening. Based on that, maybe my call would be different.” (RH2C2). Finally, the influence of the tone of the game are noted by the referee who stated the following:

The other thing which is not in the action, obviously, which would make me make a call different than what I am just making, is if in the past in the game there was some dangerous tackle, and some dangerous play that because of the past history of the game (...) makes me want to be more tough on these plays for reasons other than the play itself. So the play could be different if I had other reasons from what we just saw. (Participant RH7CF1).

In the previous sections, the advantage law is mentioned as a feature of the game which made using certain measures difficult. Its use was thus postulated to have an influence on a referee’s decision making regarding specific plays. This was the case regardless of the fact that referees were instructed to consider decisions without use of this law. Further to this, it is postulated that the advantage law is used in a greater context than just from play to play: that it is used, rather, in the game as a whole. To illustrate, one referee commented:

(...) There’s a sympathy for the game rather than just the rules. I think, o.k., technically that player’s in front of the ball, but when they’re losing by 45 points, I mean, are you really going to blow that up and bring it back? In the context of the game, is that doing anything to the players who are playing? Probably not. If it’s a tight game, and obviously you’re calling everything, then sure you’d call it. (Participant LRC8F1)

This use of the advantage law in a broader context than just from play to play becomes a feature particular to the sport. It colours the game and allows for the discretion and interpretation of the individual referee moreso than in other sports. It is in fact a note subsequent to the advantage law that "(t)he referee is given a wide discretion as to what constitutes an advantage and is not limited to territorial advantage. The referee is the sole judge of whether advantage has been gained." (1997, IRFB Handbook, p. 134). The advantage law can thus be considered the law which is the most difficult to enforce, as it calls for the greatest amount of judgment and personal interpretation on the part of the referee. In fact, one referee opined that the advantage law and its use are what make rugby refereeing an art.

The use of judgment in enforcing laws enters into a discussion of the types of rules being employed by the referees. Trudel, Dionne, and Bernard (1998) discussed the use of constituent rules and normative, unwritten rules. In their investigation of game and laboratory ice hockey referees, it was concluded that context features of the actual games such as pressure from spectators and interactions with players brought referees to shift from incorporating constituent rules to incorporating normative rules. In contrast, this shift did not seem to be in evidence with the rugby referees. It seems that the laboratory referees also attempted to maintain a use of normative functioning employing situational characteristics, and in fact often became frustrated with the lack of access to situational information. Employing situational information and individual judgement is, however, a function of the constituent rule of the advantage law. It is therefore proposed that in fact, rugby operates uniquely with a system of constituting normative rules, as it



were. That is, there is a constituent rule (the advantage law) dictating the use of normative rules.

As mentioned, the difficulties encountered highlighted the complexity and uniqueness of rugby referees as a sporting population. In further consideration of the method and population, it was proposed that sport monitors be classified according to their task demands. Similar to Poulton's (1957) discussion of task requirements for sport performers, a description of task demands for different sport monitors could be used to guide methodologies for investigating their performances. The purpose of the following sections, then, is to raise points as potential considerations were one to develop a discussion of task requirements of sport monitors. Toward this end, the limitations of the present study will be addressed. After addressing sampling limitations, those that arise from the inferred differences between the rugby referee and the gymnastics judge will be highlighted. The two types of sport monitors will be contrasted, and links will be made with the literature reviewed in chapter 2, as well as additional concepts.

#### Additional Limitations

In addition to the method, limitations were also present in sample selection due to the restricted availability of rugby referees in the Ottawa/Montreal area. As such, the sample consisted of 12 high and 12 low experience referees. The small population from which the sample was drawn necessitated a loosening in criteria for inclusion. That is, too rigid a control of factors such as the number of games refereed per year and the criterion for high and low experience would have excluded many potential participants. A greater total number of participants was thus chosen over more rigid control of these factors.

A great deal of the remaining limitations of the study were accounted for in the differences between the gymnastics judge and the rugby referee. As mentioned, the methodology for this study was based on that of Ste-Marie (1998); a study done with gymnastics judges. Both studies were conducted in laboratory settings, and therefore suffered from the obvious limitations. The tasks performed by both the judges and referees differed from the task normally performed. In both cases, there were environmental factors missing. That is, the settings were both closed and quiet. As well, decisions being made had no real impact on the actual outcome of the performances, and thus the evaluators were somewhat removed from the task, with distractions at a minimum. Additionally, the clips presented actions in isolation of the total performance, lacking significant lead in footage, and the angles of view, magnitude of the image, and distance from the action were different to what would normally be viewed. As discussed, this lacking of situational information creates difficulty in incorporating normative rules.

When the same method was used for the rugby refereeing population, additional limits to those encountered by the gymnastics judges were evidenced. First, the clips were selected to represent actions with infractions and actions without infractions. In order to do this, referees were forced into a situation where they were asked to referee when they normally would not be refereeing. Simply watching a player legally tap a ball with his foot does not require a decision on the part of a rugby referee, whereas the gymnastics judge must evaluate the performance of all moves for form break and errors. Also, in contrast to gymnastics judging, a rugby referee does not know when judgements will have to be made. It is usually clear when a move or a likely move to be evaluated will occur in gymnastics. In comparison, anything can occur in any location in rugby,

and the action can suddenly be taken from a proximal location to one a great distance away to which a referee must locate him or herself. Further, the rugby referee must consider a total of 30 players in different locations on a large field. Thus, what a gymnastics judge is missing from the angle of view or camera position in viewing video clips is negligible when considered in comparison to what the rugby referee misses.

This discussion creates a clear link to an established taxonomy for task description. Poulton's (1957) description of tasks incorporated the terms open skilled and close skilled. In an open skill, the performer must adapt his or her movements to a changing environment. Refereeing rugby is therefore classified as an open skill task in that the referee must adapt to the changing locations and positions of the players as well as the ball. A gymnastics judge, on the other hand, is stationary and does not adjust according to the performers, making the task a closed skill.

Given the open and closed skill labels, anticipation is used in different ways in the cases of the gymnastics judge and the rugby referee. A gymnastics judge who is not concerned with positioning anticipates the decision or judgment to be made. For example, a judge may note a gymnast's lack of height during a back tuck, and anticipates problems with the landing and thus point reductions. In contrast, a rugby referee's positioning is important for viewing the action about which a decision is being made. This results in anticipation first being used for positioning and then for judgment. To exemplify, if a referee does not anticipate a kick, he or she will be slower to adjust to a new position on the field, making judgment involving the kick secondary to arriving in the right position. If, however, a kick is anticipated, then a referee can begin to move

towards the appropriate new position, and begin to focus on anticipating if an infraction is likely to occur.

Description of anticipation in rugby referees elucidates some of the difficulty experienced in its measurement. In the laboratory, referees were stationary, viewing rugby plays on a screen. This view represented only a portion of the entire game action. Notwithstanding the other difficulties discussed, referees' comments were clearly made in anticipation of positioning, and not of judgments. Even the final judgment was effected by positioning, as in the case of the referee who commented that he "...could have called a high tackle, but it all depends on the positioning of the referee. It's a touchy one." (Participant RH5F1C).

It is clear, then, that even in light of the limitations of the sample and of the laboratory situation as outlined above, monitoring actions from a stationary position replicates gymnastics judging better than it replicates rugby refereeing. In addition to this, each referee has preferences in where to position him or herself at plays such as lineouts or kicks, whereas gymnastics judges are placed in a position which is relatively stationary. Thus, the initial premise that the method used with gymnastics judges by Ste-Marie (1998) would be transferable to rugby refereeing was perhaps ill considered. The difference in the responsibilities of these two sport monitors became clear as data collection and analysis proceeded. Further, these differences led to reflections upon the population of sport monitors as a whole and the differences between the various types. These thoughts are presented by way of contrasting task requirements and are framed in consideration of future research designs with this varied and understudied population.

### Thoughts on the population of sport monitors

In follow up to the limitations of this study are further thoughts regarding the population of sport monitors. At research conceptualization, it was felt that researching a sport monitor did not require a specific analysis of the *type* of sport monitoring being performed. That is, it was felt that general characteristics of the sport monitor were sufficient task descriptors for design considerations. It is now felt that this is not the case, and that researchers must consider the specific population of study. As such, the following section will first present some general considerations as common characteristics to all sport monitors. Following this will be discussion of what are felt to be defining characteristics which distinguish some sport monitors from others.

It is to be noted here, though, that conceptualizations and re-conceptualizations about common and defining characteristics revealed some insufficiencies. For example, the sport monitors of combat sports such as boxing and karate presented a problem for some of the considerations. This type of sport monitor will thus be left out of this discussion. Further to this, although it is considered that these postulations can be inferred to the other sport monitors, the ideas presented here will be based on the two populations of gymnastics judges and rugby referees.

Common characteristics. In consideration of the tasks performed by sport monitors, attention is a key concept and a common characteristic. As such, different related topics can be addressed. The first of these is attentional demands. Attention refers to "...engagement in the perceptual, cognitive, and motor activities associated with performing skills" (p. 102, Magill, 1998). As such, a skill can be analysed by how demanding it is of the different systems and the pool of attention from which they must

draw. Consider, then, that the rugby referee must watch the play for infractions, keep track of the score and the time, and move about the field all at once. These tasks each demand a certain amount of attention. Similarly, the gymnastics judge must watch the performance while writing down the point deductions from knowledge and memory of performance guidelines. Attentional demands can thus be analysed and compared between different sport monitors.

Also within the general area of attention is the concept of attentional focus. This concept describes the focusing of attention on a given stimulus, and as such is often referred to as broad or narrow (Magill, 1998). In the case of the gymnastics judge monitoring one gymnast, the focus of attention is relatively narrow when contrasted to that of the rugby referee where the stimulus is the entire game with 30 players moving about a relatively large surface. It is also acknowledged that attentional focus can shift within one task, and thus must be considered for descriptions of sport monitors.

It is further proposed that a ratio be devised for the number of monitors to performers. This ratio could then be used to describe the attentional requirements of a sport monitor for their given sport, with a low ratio requiring a broader focus, and a high ratio facilitating a narrower focus. In this manner, rugby, which has one referee and thirty players, would have a low ratio of one to 30. In a gymnastics competition, by contrast, there may be a comparatively high ratio of four judges to one gymnast.

The final topic within the area of attention is that of vigilance. Vigilance is based on the duration of attention that needs to be maintained and the frequency of the signal of focus (Magill, 1998). Thus, a rugby referee must remain vigilant for a longer duration than a judge (80 minute game versus 10-90 second performance), with a lower frequency

of signals occurring for a referee than for a judge, depending on the level of performance being monitored.

Bringing back the discussion of a monitor to performer ratio, it is acknowledged that increasing the number of gymnastics judges does not change the breadth of attentional focus of any one judge, however, it could impact the needed vigilance. That is, in a competition with four judges, any one judge is aware of the possibility that when he or she misses information, another judge may not have missed it, and thus there is potential for compensation. With a greater number of judges, then, vigilance may not be as crucial. Although ideally the vigilance level remains constant regardless of the number of monitors, perhaps it is the case that performance is improved through awareness of the compensatory monitoring of another judge, and the resulting decrease is in anxiety rather than vigilance.

Another commonality is that all sport monitors must process information and arrive at a decision based on this processing, be the decision a final score or a blown whistle for an infraction. This processing can flow through both “bottom-up” and “top-down” processing channels. Bottom-up processing is defined as data driven in that the processing is related to the stimulus and not to previous expectations or experiences (Jacoby, 1983). In theory, all sport monitors are expected to be objective, external decision makers. In practice, however, studies show (e.g., Trudel et al., 1998) that in fact, decisions are frequently influenced by top-down, experience referenced processing in which an individual will use expectations that are determined by the context and past experience.

For example, research has shown the existence of biases in gymnastics wherein previous presentation of a gymnast's performance will influence a judge's later evaluation (Ste-Marie & Valiquette, 1995). Similarly, it has been mentioned that, throughout this study, the context or specific situation in which an event took place heavily influenced the decision making of rugby referees. The link was thus made to normative, situational rule employment, which can further be linked, then, to what has been described as top-down processing (Trudel et. al., 1998). In sum, although perhaps processing should be primarily bottom-up, sport monitors have influences of both top-down and bottom-up processing.

Further to processing distinctions are the information sources associated with this processing. The same links can thus be used here as those discussed in relation to the information sources measured in this study. These links address the predominant memory/knowledge structures being used by the judge and the referee. Indeed, using past experience implies that these sport monitors rely heavily on episodic memory.

Defining characteristics. In addition to these common characteristics of different sport monitors, a discussion of defining characteristics can be used for categorization purposes. The first distinction arises from the purpose and impact of the sport monitor upon the outcome of the performance. This distinction was used to label monitors as either evaluators or enforcers. The role of the evaluator is to determine the quality or merit of performance as indicated by the performance criteria. The functions of a gymnastics judge exemplify this. In contrast, the enforcer does not determine the quality of a performance, but facilitates the outcome by enforcing the performance criteria and



noting the points awarded as a result. The enforcer thus provides a description of the rugby referee.

A further distinction between evaluators and enforcers can be discussed in terms of their relationship to the flow of performance. The two types of monitors are thus distinguished by their ability to stop and start the performance. While an evaluator signals for the beginning of a performance, the athlete is not stopped until the performance is completed. For example, a judge signals a gymnast to begin her routine. The gymnast salutes and proceeds. Although there will be contradictions of the performance criteria such as perhaps a fall from the beam, the evaluator simply notes these contradictions but does not stop the performer. As such, the evaluator's task is self-paced in that he or she determines the point at which monitoring will begin.

In contrast, an enforcer not only notes contradictions of performance criteria, but stops the performance to correct these contradictions. Thus, a rugby referee will note a penalty infraction, blow his whistle, and inform the players that an infraction has occurred and one team is therefore being penalized. Except at re-starts, then, the tasks of enforcing sport monitors are thus performer paced rather than self paced. That is, the enforcer does not determine when enforcing will begin and stop as it is ongoing, and not as temporally finite as in the case of the evaluator.

Related to a monitor's impact on the flow of the game is their interaction or lack thereof with performers. In discussing this aspect of monitor performance, one type of evaluator, and three types of enforcers are proposed. In evaluated sports, the sport monitor acts independently from a performer, and is thus labeled an "actor". The judge evaluates the performance with virtually no interaction or communication with the

performer. This type of sport monitor is also heavily implicated in the performance outcome in that his or her actions are related to point deductions and the subsequent cumulative score.

For sport enforcers, there are three categories based on interaction and communication. A “react” category involves a sport monitor who reacts to specific actions of the performer(s). An example in this case is the rugby touch judge or tennis line judge who may make a call in reaction to the location where a ball alights. In this case, the actions of the monitor are more dependent on the performer’s actions and are not delayed temporally, as in the case of the “actor”. There is also an increase in the interaction between the monitor and performer from the “actor” to “reactor”, however, the “reactor” is limited to conveying relatively small amounts of information.

In an “interact” sport, a larger amount of information is communicated from the monitor to the performer. Additionally, in contrast to the “actor” and the “reactor”, the “interactor” is on the same playing surface as the performer. Interpersonal qualities and interpretation become important for this sport monitor. In the case of the soccer referee who runs alongside the player, he or she may be aware of the unevenness of the terrain which, rather than being tripped by the opposition, caused a player to fall. Further, the increased interaction between player and monitor allows for the inclusion of interpersonal factors, such as the case where a referee ejects a player because he has taken exception to the manner in which the player is arguing with him.

Although the same, the factors relevant for the “interactor” are heightened in the case of the referee monitoring a contact sport. While injury may be a concern in all sports, the contact monitor must have an increased awareness for interactions between the

athletes which may lead to injury. Thus, more interpretation is warranted. Recall, for example, the quotation noting that the intention of the player to perform a dangerous play was a factor in whether the rugby referee called a penalty or not. Once again, then, interpretation, and interaction with the players become factors.

The concepts reviewed in comparison of varying sport monitors represent preliminary considerations, and as such, further concepts obviously merit analysis. For example, the task of the sport monitor is influenced by the mobility required throughout the performance. When considered in conjunction with the size of the playing or performance surface being monitored, one may analyse the physiological demands for various umpires, referees and judges. Perhaps differences also exist when considering interaction with coaches and spectators. It is hoped, then, that this discussion highlights the fact that one cannot consider all sport monitors as engaging in the same process with the same task demands. That is, similarities exist, but we must also be mindful of differences, especially when conceptualizing research protocols.

## Thesis References Not in Article

- Abernethy, B. (1987). Anticipation in sport: A review. Physical Education Review, 10 (1), 5-16.
- Abernethy, B. (1991). Visual search strategies and decision-making in sport. International Journal of Sport Psychology, 22, 189-210.
- Abernethy, B., Neal, R. J., & Koning, P. (1994). Visual-perceptual and cognitive differences between expert, intermediate, and novice snooker players. Applied Cognitive Psychology, 8, 185-211.
- Allard, F., & Starkes, J. L. (1993). Cognitive issues in motor expertise. North-Holland: Elsevier Science Publishers
- Bard, C., Fleury, M., & Goulet, C. (1994). Relationship between perceptual strategies and response adequacy in sport situations. International Journal of Sport Psychology, 25, 266-281.
- Bereiter, C. & Scardamalia, M. (1993). Preface. In C. Bereiter, & M. Scardamalia (Eds.), Surpassing ourselves. (pp. ix-xiii). Chicago, IL: Open Court.
- Chase, W. G., & Simon, H. A. (1973). The mind's eye in chess. In W. G. Chase (Ed.), Visual information processing. (pp. 215-281). New York: Academic Press..
- deGroot, A. (1978). Thought and choice in chess. The Hague: Mouton.
- Ericsson, K. A. (1996) The acquisition of expert performance in the road to excellence. In K. A. Ericsson (Ed.), The acquisition of expert performance in the arts and the sciences, and sports, and games. (pp. 1-49). Mahwah, NJ: Lawrence and Associates.
- Ericsson, K. A., & Charness, N. (1994). Expert performance: Its structure and acquisition. American Psychologist, 49 (8), 725-747.

Ericsson, K. A., Krampe, R. T., & Tesch-Romer, C. (1993). The role of deliberate practice in the acquisition of expert performance. Psychological Review, *100*, 363-406.

French, K. E., & Thomas, J. R. (1987). The relation of knowledge development to children's basketball performance. Journal of Sport Psychology, *9*, 15-32.

Garland, D.J., & Barry, J. R. (1990). Sport expertise: The cognitive advantage. Perceptual and Motor Skills, *70*, 1299-1314.

Garland, D. J., Barry, J. R. (1991). Cognitive advantage in sport: The nature of perceptual structures. American Journal of Psychology, *104* (2), 211-228.

Gilbert, W. D., Trudel, P., & Bloom, G. A. (1995). Intramural ice hockey officiating: A case study. Avante, *1* (1), 63-76.

Hammond, K. R. (1993) Naturalistic decision making from a Brunswikian viewpoint: Its past, present, and future. In G. A. Klein, J. Orasanu, R. Calderwood, & C. E. Zsombok (Eds.), Decision making in action: Models and methods. (pp. 205-227). Norwood, NJ: Ablex.

International Rugby Football Board, (1997). Handbook, 1997. (Handbook).

Jacoby, L. L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. Journal of Experimental Psychology: General, *110* (3), 306-340.

Klein, G. A. (1993). A recognition-primed decision (RPD) model of decision making. In G. A. Klein, J. Orasanu, R. Calderwood, & c. E. Zsombok (Eds.), Decision making in action: Models and methods. (pp. 138-147). Norwood, NJ: Ablex.

Klein, G. A., & Hoffman, R. R. (1993). Seeing the invisible: Perceptual-cognitive aspects of expertise. (pp. 203-226). In M. Rabinowitz (Ed.), Cognitive science foundations of instruction. Hillsdale: Erlbaum.

Lipshitz, R. (1993). Converging themes in the study of decision making in realistic settings. In G. A. Klein, J. Orasanu, R. Calderwood, & C. E. Zsombok (Eds.), Decision Making in Action: Models and Methods. (pp. 103-137). Norwood, NJ: Ablex.

Magill, R. A. (1998). Motor Learning: Concepts and Applications (Fifth Edition). Louisiana State University: McGraw Hill.

McLennan, J. & Omodei, M. M. (1996). The role of prepriming in recognition-primed decisionmaking. Perceptual and Motor Skills, 82, 1059-1069.

Newell, A., & Simon, H. A. (1972). Human problem solving. Englewood Cliffs, NJ: Prentice-Hall.

Orasanu, J. & Connolly, T. (1993). The reinvention of decision making. In G. A. Klein, J. Orasanu, R. Calderwood, & C. E. Zsombok (Eds.), Decision making in action: models and methods. (pp. 3-20). Norwood, NJ: Ablex.

Partridge, D. (1998, February 8). Incompetent referees.  
<http://www.rugbyreferee.NZ>.

Rasmussen, J. (1993). Deciding and doing: Decision making in natural contexts. In G. A. Klein, J. Orasanu, R. Calderwood, & c. E. Zsombok (Eds.), Decision making in action: models and methods. (pp. 138-147). Norwood, NJ: Ablex.

Ripoll, H., Kerlirzin, Y., Stein, J.-F., & Reine, B. (1995). Analysis of information processing, decision making, and visual strategies in complex problem solving sport situations. Human Movement Science,14, 325-349.

Russell, S. J., & Salmela, J. H. (1992). Quantifying expert athlete knowledge. Journal of Applied Sport Psychology, 4, 10-26.

Starkes, J. L. (1987). Skill in field hockey: The nature of the cognitive advantage. Journal of Sport Psychology, 9, 146-160.

Starkes, J. L., & Deakin, J. (1984). Perception in sport: A cognitive approach to skilled performance. In W. F. Straub & J. M. Williams (Eds.), Cognitive sport psychology, (pp. 115-128). Lansing, NY: Sport Sciences.

Ste-Marie, D. M. (1998). Expert-novice differences in gymnastics judging. Journal of Applied Cognitive Psychology, (In press).

Ste-Marie, D.M., & Lee, T. D. (1991). Prior processing effects on gymnastics judging. Journal of Experimental Psychology: Learning, Memory, and Cognition, 17, 126-136.

Ste-Marie, D. M., & Valiquette, S.M. (1996). Enduring memory-influences biases in gymnastics judging. Journal of Experimental Psychology: Learning, Memory and Cognition, 22 (6), 1498-1502.

Tenenbaum, G., Levy-Kolker, N., Sade, S., Lieberman, D. G., & Lidor, R. (1996). Anticipation and confidence of decisions related to skilled performance. International Journal of Sport Psychology, *27*, 293-307.

Thomas, K. T., & Thomas, J. R. (1994). Developing expertise in sport: The relation of knowledge and performance. International Journal of Sport Psychology, *25*, 295-312.

Trudel, P., Dionne, J.-P., & Bernard, D. Differences between assessments of penalties in ice hockey referees, coaches, players, and parents. In A. B. Ashare, (Ed.) Safety in ice hockey: Third Volume. (In press).

Weinberg, R. S. & Richardson, P. A. (1990). Psychology of officiating. Champaign, IL: Human Kinetics.



**SECTION IV**

## Appendix A: Contributions of Collaborators

The article resulting from this thesis work has two authors. This indicates the collaborative efforts of Diane Ste-Marie and myself. Specifically, the involvement of each author in the research processes will be outlined.

A key article of interest was obtained in which Australian rules rugby referee decision making was examined. Due to my interest in the sport, rugby union was brought up as a general area in which Dr. Marie's previous research involving judging in gymnastics could be developed. As such, the research design was formulated in discussion with Dr. Ste-Marie and other graduate students in lab meetings, and modeled after Dr. Ste-Marie's work.

I myself filmed, selected, and edited all of the rugby footage and clips. Subsequent to this, I also contacted the appropriate people to obtain phone lists of participant referees, as well as the expert raters. The data collection was done by myself with the tireless and appreciated help of an undergraduate student. Additionally, the coding system was created by myself and rater checked by the same undergraduate student. The subsequent clusters for these codes were the result of suggestions by Dr. Ste-Marie. All of the data was coded by myself before data entry and the data analysis phases.

Assistance on the ANOVA analyses was provided by Dr. Ste-Marie. I was primarily responsible for the signal detection analysis and a researcher in the psychology department provided confirmation of calculations and results. Interpretation of results from these two analyses was generated in discussion between Dr. Ste-Marie and myself. All written material was first drafted by myself and then edited by Dr Ste-Marie. This

resulted in suggested improvements of the work, which have been influential and essential to the final product.

## Appendix B

**Information and Consent Form for Participants****Principal Investigators:**

Clare Mac Mahon	Dr. Diane Ste-Marie	
Graduate Student	Assistant Professor	
School of Human Kinetics	School of Human Kinetics	University of
Ottawa	University of Ottawa	
Phone number: 226-6429	Phone number: 562-5800 ext. 4255	

You may also want to contact Dr. Roger Proulx, Chair of the Faculty of Health Sciences Human Research Ethics Committee at the University of Ottawa for information concerning ethical approval of this project which is entitled "Anticipation in Decision-Making: An Examination of Expert and Novice Rugby Referees". Phone number: 562-5800 ext. 4251.

**Purpose:** The purpose of this study is to examine the anticipation and knowledge base of expert and novice rugby referees as aspects involved in decision-making.

**Demands:** This research project will involve my participation in a laboratory test of anticipation and knowledge base as related to decision-making. I will view a videotape with sequences of rugby footage. At points during the videotape where there are pauses, I will attempt to anticipate the subsequent actions. I will additionally answer questions regarding the information used in arriving at these answers. I am aware that if I no longer wish to continue with this research project, I can inform the researcher, and I am welcome to withdraw. There will be no reprisals due to my withdrawal. Any data collected to that point will be destroyed, and will not be used in the research.

**Risks/Discomfort:** Since this is laboratory test, there are no expected risks for participating in this study. The possible benefits are a better understanding of the role of anticipation in the decision-making abilities of referees, and possible recommendations in training strategies.

**Anonymity/Confidentiality:** If data is published, it will be presented in a pooled format. In addition, my name will not be placed on any of the data collection forms, ensuring anonymity and confidentiality of my results. My data will be stored for a minimum of three years ( as per research publication requirements) in a file to which only the principal investigators have access. After this time, my data will be shredded and the paper will be recycled.

The experimenter will be willing to answer any questions before, during and after the study that I may have. I will also be given a copy of this information and consent form.

I \_\_\_\_\_ (please print) have read the above information and voluntarily agree to participate in this research project.

Participant's signature \_\_\_\_\_ Date: \_\_\_\_\_  
 Researcher's signature \_\_\_\_\_ Date: \_\_\_\_\_

## Appendix C:

**Information and Consent Form for Game Coaches and Referees**

To Coaches and Referees,

My name is Clare Mac Mahon and I am a Masters student at the University of Ottawa in the School of Human Kinetics. I am conducting a Masters thesis in the field of sport psychology under the supervision of Dr. Diane Ste-Marie. I am interested in examining the roles of anticipation and knowledge base in the decision-making of expert and novice rugby referees. It is hoped that the findings from this thesis will provide insight into the acquisition of refereeing expertise leading to possible recommendations in training strategies.

In conducting the research, video taped clips of games will be used. With your permission, we would like to videotape a game from an unobtrusive position on the touchline. The videotapes will be used solely in this research. I thank you in advance for your cooperation.

Sincerely,

Clare Mac Mahon

I \_\_\_\_\_ (please print) have read the above information and agree to allow videotaped recording of the game on \_\_\_\_\_

Coach/referee signature: \_\_\_\_\_ Date: \_\_\_\_\_

Researcher's signature: \_\_\_\_\_ Date: \_\_\_\_\_

## Appendix D:

## Instructions for Decision Making Study

This study does not evaluate your personal abilities as a referee (player), but rather the process of **how** you (would) make rugby refereeing decisions. You will view videotape of a rugby play in 3 portions. Each video portion will be preceded by a beep to prepare you for viewing. The clips used will show tackles, kicks, and lineouts. The first portion of each clip will be a freeze frame of rugby footage. In the second portion, the video will stop before an action, at which point you will be asked what all the possible player options are at this point. You will then be asked to anticipate what action will follow. For the action you have anticipated, I will ask you what your call would be. You will also be asked what information you used in arriving at these answers. In the third video portion, the clip will be shown again, without being cut off. At this point, you will be asked to identify the action that you view as quickly as possible. At this point, your voice reaction time is being measured, so please try to speak only when you have a response. You will then be asked to make a call for this action, without considering the advantage law, and finally, you will be asked if there was new information that you used to come to this decision.

There are a total of 23 clips, with 5 “warm up” items. For half of these clips, you will be told the game score and the game time for the point at which the action is taking place. For half of the clips you will not be told this information. Again, we are not evaluating your abilities, but rather the process of how you arrive at a decision. I will now go through an example with you, and don’t hesitate to ask clarifying questions. Do you have any questions before we begin?

Appendix E:  
Expert Video Rating: Instructions

Each clip that you will be viewing has a 3-part format, consisting of a freeze frame, an anticipation portion and a call portion. Your role is played in the call portion of the clips, although you will view each clip in its entirety. Beeps precede each portion of the clips to prepare the viewers. For example, the clips will proceed in this way:

1. black tape (and beep)
2. freeze frame of a play, e.g. lineout - hooker with ball in hand, line set
3. black tape (and beep)
4. hooker throws ball in and the action cuts off before it is caught
5. black tape (and beep)
6. hooker throws ball in and the clip shows the ball being caught

At this point, you will compare your call for this action with the decision I have made.

There are 33 clips on this tape, which have been taken from games or staged by players. Using the sheets which follow, indicate for each clip 1) whether you agree or disagree with my decision, 2) what the referee call for that clip should be (there are many “no call” clips included), and 3) the level of clarity of the clip. **Do not confuse clarity with the difficulty level of the call being made.** Clarity should be used to indicate things such as poor tape quality or a shaky camera, action far away which is difficult to view, or obstruction of sight lines, for example, a spectator walks in front of the camera. The two example clips **will not appear on the tape** and have only been written in. Therefore, the first clip on the tape is the #1 clip from the sheet. Feel free to use any means needed to best decide on the calls. You may replay the clips as often as you like, and use slow motion. You can contact me by e-mail if you encounter any problems: [s1599924@aix1.uottawa.ca](mailto:s1599924@aix1.uottawa.ca)

**Thank you sincerely for your help with this project—you will have played a very important role!!**

Clarity:

**Poor** = do not use this clip

**Fair** = can be used, could be better

**Good** = no problems viewing

Table: Expert Raters

	Do You		Your	Clarity	Comments
Clip #	My Decision	Agree/Disagree?	Referee Call		
Example 1	legal lineout	agree	no call	good	
Example 2	high tackle	disagree	no call	fair	although it looked high, it was below the collarbone
1.	legal lineout				
2	high tackle.				
3.	legal tackle				
4.	legal lineout				
5.	inside arm down in lineout				
6.	early lift in lineout				



Appendix: F  
Code and Cluster List

Cluster 1: Declarative Semantic

Adv.: discussion of advantage or advantage law

LI: law information, e.g., “under law x, not allowed to...”

Examples from “declarative semantic” cluster

LI: “The player has to release the ball when on the ground”. (L24F1)

Adv: “ This is advantage for the team who is playing the ball”. (L24F1)

Cluster 2: Declarative Episodic

WC: weather conditions

GC: given context of time and score

KOP: knowledge of player or team; mention of level of play; player’s position, e.g., prop vs. inside center

MTN: mentions team name

IOP: intent of player; discussion of maliciousness, violence

Examples of “declarative episodic”:

IOP: “It looks like that player took exception to the previous call....” (RHC1F1)

MTN: “That’s classic (team name) stuff...classic (coach name) stuff”. (RH3CF1)

Cluster3: Procedural Seen

FP: field position, references to lines, zones

POP: position of player(s); can be static location; offensive or defensive, as related to play; proximity

MOP: movement of player(s) as related to the play. E.g., “they were coming across the field”

SA: specific rugby action, otherwise unclassified. E.g., “he kicked the ball”, or “they rucked over”.

Bod. body position of player; discussion of limbs, E.g., crouching, shoulder down.

BL: ball location, path, movement; where focal point is ball.

COE: characteristics of execution, not including body position. E.g., speed, panic, momentum.

Examples from “procedural seen” cluster

MOP: “The ball was clearly out of play and the players weren’t moving any more”. (KRHFR1)

SA: “she released the ball”

Cluster 4: Procedural Not Seen

AOV: angle of view; as problematic; suggested improvement

MI: missing information e.g., field lines, specific players

TLF: things to look for, e.g. specific infractions in this situation; what referee *would* do

Examples from “procedural not seen” cluster

TLF “ I would be looking for that fringe (positioned on the fringe of the action) player”. (RC4LF1)

MI: “I couldn’t see if the players were back ten.” (L24F1)

Remaining Codes

5. Verbal: would give verbal call/warning. E.g., in the case of a “hit no call”.
6. RP: refereeing philosophy; consideration of flow of game
7. Other: items unspecified or not otherwise classifiable
8. AOR: actions of referee: use of video referee for decisions
9. OI: other infraction: identification of infraction other than the target infraction.

(Distinguished from a false alarm in that the action was not the focus. Example: in a clip with a legal tackle as the intended focus, identification of a ball knocked forward (knocked on) = OI (k-o). In a clip of a lineout throw with no infraction, “not straight” call = false alarm.)

Appendix G: Faculty of Health Sciences HREC Approval



# Université d'Ottawa • University of Ottawa

Faculté des sciences de la santé  
Cabinet de la doyenne

Faculty of Health Sciences  
Office of the Dean

February 18, 1998



Professor Diane Ste-Marie  
Student Clare MacMahon  
School of Human Kinetics  
Faculty of Health Sciences  
University of Ottawa  
125 Université, Montpetit Hall  
INTRA

Dear Professor and Dear Student:

**Subject:** *Your project entitled "Anticipation and knowledge base in decision-making: an examination of expert and novice rugby referees"*

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It is my pleasure to inform you that the Faculty of Health Sciences, Human Research Ethics Committee, after study of the documentation provided, concluded that your project met the appropriate standards of ethical acceptability and falls within **CATEGORY 1A**.

I hereby attach a copy of the certificate of clearance granted by the University Human Research Ethics Committee.

This certificate is valid for a period of one year from the time of issuance. I would also like to remind you that, in accordance with the policies of the UHREC, it is your responsibility to notify the Committee of any major changes in this project.

On behalf of the Committee, I wish you success in your project.

Sincerely,

J. Roger Proulx, Ph.D.  
Chair, Human Research Ethics Committee

Encl.



# Université d'Ottawa - University of Ottawa

Faculté des sciences de la santé  
Cabinet de la doyenne

Faculty of Health Sciences  
Office of the Dean

## CERTIFICATION OF INSTITUTIONAL HUMAN RESEARCH ETHICS COMMITTEE FACULTY OF HEALTH SCIENCES

This is to certify that the Institutional Human Research Ethics Review Committee of the Faculty of Health Sciences has examined the research proposal from **Professor Diane Ste-Marie and Student Clare MacMahon** from the School of Human Kinetics for the project "*Anticipation and knowledge base in decision-making: an examination of expert and novice rugby referees*" and concludes that, in all respects, the proposed research protocol meets the appropriate standards of ethical acceptability, at a **Category 1A** level.

### MEMBERS OF THE COMMITTEE

<u>Name (Optional)</u>	<u>Position held</u>	<u>Department of discipline</u>
Victor Boucher	Professor	Audiology and Speech-Pathology Program
François Tremblay	Professor	Physiotherapy Program
Claire-Jehanne Dubouloz	Professor	Occupational Therapy Program
Jocelyne Tourigny	Professor	School of Nursing
Julian Roberts	Professor	Department of Criminology
Roch Paquin	Member-at-Large	
Mark Grenier	Student	School of Human Kinetics
J. Roger Proulx	Chair	Human Research Ethics Committee School of Human Kinetics

### SIGNATURE

18/02/198

Date

Committee Chairperson - J. Roger Proulx, Ph.D.