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Assessing the quality of decision-making of expert rugby players

by

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SUMMARY

The study of cognition as it relates to expert performance in sport is an area that has received increased attention over the last 25 years. This has been made possible by the fact that the domain of sport offers a rich and diverse setting in which to study cognition and its links to human performance, coupled with the abundant supply of highly practiced athletes providing unique opportunities to study these factors in a natural environment. The quality of on-field decision-making of expert athletes has received attention in a number of open-skill sporting codes, including basketball, field hockey and soccer. Decision-making quality of expert athletes in rugby union, as an invasive, open-skill sporting code, has not received the same amount of attention.

Past studies on the decision-making of expert athletes in sport have tended to be carried through the isolation of specific cognitive functions and describing the role of each isolated function in the decision-making process. Given the speed at which decisions have to be made, as a result of time pressure, the isolation of cognitive functions yields valuable insights into the decision-making processes of expert athletes in competitive, on-field situations. While these cognitive functions can be studied in isolation, they do however form part of a bigger process that enables the expert athlete to make high quality on-field decisions. It is for this reason that it was decided to study these different functions in combination, as set out by the Information Processing Approach to cognitive functioning. According to this approach, the decision-making process consists on three main phases, namely that of Visual Search Strategies, Anticipation and Response Selection.

This study was aimed at examining the quality of on-field decision-making of expert rugby players, as well as the influence of the competitive level at which rugby is played on decision-making quality. In order to achieve this goal it was necessary to develop a measurement instrument that can be used by expert rugby players to assess the quality of decisions made on the field of play. As it is difficult for outside observers to establish what players are thinking or focusing their attention on when making decisions on the field, it was necessary to design the instrument as a self-report measure of decision-making.

By being made aware of one's strong and weak points in on-field decision-making, expert rugby players can focus their attention on improving the underdeveloped facets of their game. The measurement of decision-making according to three distinct phases allows for increased accuracy in the identification of those cognitive areas that need improvement in order to improve overall playing ability. By changing the way the expert rugby player thinks about certain aspects of the game, most notably those aspects that the player has difficulty with, it becomes possible for the player to address these difficulties and make improvements wherever necessary.

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Key Terms

Decision-making

Quality

Rugby

Expert players

Information Processing Approach

Visual Search

Anticipation

Response Selection

Measurement

Playing level

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1. INTRODUCTION

1.1 RESEARCH PROBLEM

The study of cognition as it relates to expert performance in sport is an area that has received increased attention over the last 25 years (Starkes, 2003). Aspects of cognitive functioning that have been studied include among others sensation, attention, visual perception and search strategies (Williams & Ericsson, 2005), anticipation, concentration, short-term and long-term memory (Singer, Murphy & Tennant, 1993), reaction time (Ericsson, Patel & Kintsch, 2000), motor performance, experience and decision-making (Summers, 2004). This has been made possible by the fact that the domain of sport offers a rich and diverse setting in which to study cognition and its links to human performance. Coupled with the abundant supply of highly practiced athletes (Abernethy, Maxwell, Jackson & Masters, 2007), these studies may provide unique opportunities to research these factors in a natural environment.

The quality of on-field decision-making of expert athletes has received attention in a number of open-skill, invasive sporting codes including basketball (Raab, 2001), field hockey (Williams, Ward & Chapman, 2002) and soccer (Ward, Williams & Ericsson, 2003). Studies of this nature have focused primarily on isolating one of the cognitive functions mentioned above, with little emphasis placed on the integration of these factors within a coherent information processing model, although some efforts have been aimed at this goal (Tenenbaum, 2003). As a result, the measurement of these cognitive processes has also been done through the isolation of single factors, for example studying the effects of visual occlusion on visual search strategies (Savelsbergh, Williams, Van der Kamp & Ward, 2002), yielding empirical data that does not lend itself to integration within the entire decision-making process.

It is however very difficult to study the entire decision-making process while it is taking place in a natural, on-field/court situation, with the main reason being that the athlete is seldom aware of all the cognitive processes involved in making a decision under time-pressure (Schmidt & Wrisberg, 2004). Although efforts have been made to study and measure expert players quality of on-field level of decision-making in a more integrated fashion (Elferink-Gemser, Visscher, Richart & Lemmink, 2004), no efforts have been made to study and measure this cognitive process as it operates in the on-field decisions made by expert rugby players. The main objective of this research is therefore to identify the central components of high quality decision-making that can be used to develop a measurement inventory for expert rugby players to assess the quality of decisions made on the field of play, while under time pressure, after the match has been completed. This study will incorporate aspects of declarative and procedural knowledge, as it represents a common way of categorizing the cognitive skills needed in sports (Turner & Martinek, 1999), as well as elements of both motor skills and tactical skills (McPherson &

Kernodle, 2003). The correct use of this inventory should allow the expert rugby player to arrive at a valid and reliable measure of the quality of his own on-field decision-making, by integrating the most important cognitive aspects of decision-making taking place under time pressure in the natural game-situation.

1.2 LITERATURE REVIEW

A number of approaches have been followed in studying the cognitive functioning of expert sports men and women in on-field, sport related situations, with the most frequently applied approaches being the expert-novice paradigm, the naturalistic decision-making (NDM) paradigm and the information processing approach. Each of these approaches emphasize different aspects of expert decision-making under time pressure and use different measurement techniques to assess the quality of decision-making made in natural situations. Before discussing each of these approaches, a brief overview will be given of their theoretical assumptions as they pertain to the topic under discussion.

1.2.1 OVERVIEW OF KEY CONCEPTS AND THEORETICAL ASSUMPTIONS

Although the approaches mentioned above were not originally designed for application in a sporting context, with the exception of the expert-novice paradigm, they do share some important aspects that make their application within this context worthwhile. Firstly, these approaches differ from what are known as rational or normative decision-making models (Lehto, 1997) which have primarily focused on how people should make decisions according to some optimal framework, characterized by sufficient time and information (Wickens & Hollands, 2000). These types of models are deterministic in nature in that they assume that the option with the highest expected utility will always be selected (Johnson, 2006). The expert-novice paradigm, the naturalistic decision-making (NDM) paradigm and information processing approach, on the other hand, are known as probabilistic or dynamic models, as they look to incorporate the variance of human behaviour. They are further characterized as investigating decision-making in settings that are marked by ill-defined goals, shifting conditions, high levels of uncertainty, time pressure, ambiguous or incomplete information and multiple players (Pliske & Klein, 2003). Time pressure is particularly important in the study of decision-making in expert rugby players, as these players seldom have more than a few seconds to make a decision. Taking all of these factors into account, it would seem that these probabilistic models are much more appropriate for studying decision-making and the quality thereof in dynamic environments like a rugby match, than are the models used to predict behaviour in well-structured situations in a deterministic, linear fashion.

High levels of experience in the natural decision-making situations are a precondition for studying the quality of decision-making according to these probabilistic approaches. Ericsson (1996) found that in most cases, ten years of deliberate practice is required for an individual to achieve a level of motor and cognitive expertise in sport. Sport scientists have however experienced difficulty in producing empirical evidence for Ericsson's proposal, with Salmela (1999) suggesting that this lack of success may be due to qualitative differences in the nature of competitive sports. Considering that players as young as 20 years have recently represented the (national rugby team of South Africa) Springboks, the ten years of deliberate practice criteria proposed by Ericsson (1996) seems to be of limited value.

Finally, it must be noted that to date, no consensus has been reached on what high quality or good decision-making entails (Shanteau, 1992). One approach has been to say that 'good' decisions are those that produce 'good' outcomes (Klein, 1996) entailing that the decision-maker can only judge his/her decision quality in retrospect of the outcomes. This approach is not entirely satisfactory, as the outcomes of decisions are more often than not reliant on other players in a team, enhancing the possibility than good initial decisions can have 'bad' outcomes as a result of subsequent on-field actions of other players, placing the outcome beyond the control of the decision-maker. Another approach to decision quality is based on the concept of expertise whereby a decision is judged as being good when it can be assumed that an expert in the field would have done the same in a similar situation (Baker, Côte & Abernethy, 2003). The problem is that experts do not always make better decisions than novices (Shanteau, 1992), often resulting in highly skilled players making elementary on-field mistakes. A final approach to judging the quality of on-field decisions proposed by Schmidt and Wrisberg (2004) is to judge decisions according to the advantage they produce over a player's opponent. If a decision, regardless of the execution of the accompanying action, can be judged to produce an advantage over one's opponent in most situations it is employed in, then it can be regarded as being a high quality decision. For the purpose of this study, the approach will be adapted that, when all three of these characteristics converge, it becomes easier to discriminate good from bad decision-making.

1.2.2 APPROACHES TO STUDYING DECISION-MAKING IN SPORT

Having discussed the basic concepts of central importance to these probabilistic models of decision-making, namely that of experts making decisions in dynamic situations under extreme levels of time pressure, the remainder of this section will be used to discuss each of these approaches in detail as they incorporate these concepts and their influence on the quality of decision-making in sport.

1.2.2.1 THE EXPERT-NOVICE PARADIGM

The most direct approach to examine differences in the skill level of individuals is to compare the competence of beginners, average performers and experts on various characteristics of perceptual-motor performance (Wrisberg, 2001). As previously mentioned, the performance advantage enjoyed by experts is due to domain-specific cognitive, perceptual and motor capabilities developed over many years of sporting experience (Abernethy, 1999a) and considering that this approach was developed with the sporting context firmly in mind (Chase & Simon, 1979) some very interesting findings have been made. Studies of this nature have typically involved the isolation and comparison of specific perceptual processing capabilities, sport specific knowledge, or the mechanical efficiency of expert athletes and non-expert athletes (Wrisberg, 2001).

To date, no attempt has been made to incorporate all of the findings of the expert-novice paradigm into a coherent model of expert skill and decision-making as a process. This may be a result of the deliberate practice theoretical framework's inability to explain and predict expertise in the motor domain (Abernethy, Farrow & Berry, 2003), although findings obtained from these studies do shed some light on the specific cognitive skills possessed by expert sportsmen and women. For example, it has been found that more skilled athletes encode/retrieve game structure information differently and/or more quickly (Christensen & Glencross, 1993), use more efficient visual search strategies (Abernethy, 1991) and also selectively attend to different kinds of information in the sports environment (Tenenbaum & Summers, 1996). Furthermore, experts are characterized by superior pattern recognition and anticipation skills (Abernethy, Farrow & Berry, 2003), superior decision-making skills especially in terms of declarative and procedural knowledge (McPherson & Kernodle, 2003), as well as superior movement execution skills (Janelle & Hillman, 2003).

Viewed separately, these results have led to some important insights regarding the perceptual-cognitive and motor skills of expert athletes, but the failure to integrate these results deals some damage to the approach as a whole. This failure of integration is understandable, as the in-depth study of these functions relies on the isolation of each aspect of cognitive functioning, with subsequent measurement of each aspect relying on the use of very expensive technological techniques. This leads to an increased difficulty in describing and explaining the processes that occur between the recognition and encoding of visual information to the selection of an appropriate behavioural response or action, being the main characteristics of decision-making.

1.2.2.2 THE NATURALISTIC DECISION-MAKING PARADIGM

Naturalistic decision-making (NDM) can be defined as the study of how people use their experience to make decisions in field settings (Zsambok & Klein, 1997). The most important element of this definition is the emphasis on experience, as NDM researchers believe that many important decisions are made by people with domain experience, making it important to study how people use their experience to make decisions (Pliske & Klein, 2003). A number of conditions have been used to describe decision-making in natural settings according to the NDM-perspective, with the most important aspects including time pressure, uncertainty, dynamic conditions, ill-defined or multiple goals, feedback loops, multiple players and high stakes associated with particular decisions being made (Orasanu & Connolly, 1993). This perspective fits in well into the class of dynamic decision-making models, as it is not aimed at predicting decision-making behaviour, but rather at understanding or describing how it takes place within a naturally occurring environment.

The NDM perspective has been predominantly used in studies of human factors and ergonomics, as it was originally designed to study how people in the military, aviation and other applied settings perform their jobs and make 'on-line' decisions (Pliske & Klein, 2003). All of these natural settings are characterized by decision-making occurring under situations of stress, time pressure, and uncertainty. Specific studies have looked at the decision-making of, for example, navy command and control specialists (Wohl, 1981), fireground commanders who supervise and command teams of fire fighters (Klein, Calderwood & Clinton-Cirocco, 1989), physicians and surgeons (Dawson, Connors & Speroff, 1993) and military pilots and weather forecasters (Pliske, Crandall & Klein, 2004). Although very applicable, this perspective has not been used to study the on-field decision-making of expert athletes competing in open-skill sports. The main for reason for this might be the fact that NDM is primarily aimed at describing the conscious processes that lead to decisions being made by experts in the field (Sieck & Klein, 2007), rather than finding ways to uncover the underlying processes that operate in the making of a decision.

Although some models have been developed to describe the components of expert decision-makers (Klein, 1998), the methods employed in the NDM perspective have been criticized for using primarily verbal reports in decision research, with the argument being that experts are conscious of the products of their mental processes but not of the decision processes themselves (Sieck & Klein, 2007) that underlie these conscious mental processes. These methods have however been used in the design and development of technological and training solutions which have led to significant increases in the quality level of on-line decision-making of experts in their natural work environments (Hollnagel, 2002). As mentioned above, this approach is not aimed at uncovering the underlying cognitive structures of decision-making and it is therefore not the best method by which to determine the structure and quality of decision-making in expert rugby players.

1.2.2.3 THE INFORMATION PROCESSING APPROACH

In its most basic form, the information processing approach can be conceptualized as consisting of three distinct stages in information processing, namely the stimulus identification, response selection and response programming stages (Schmidt & Wrisberg, 2004). Although not originally designed for use in sporting contexts, the information processing approach has been applied with great effect in studying the decision-making and other cognitive functions of expert performers in sport in its original form (shown in Figure 1; Summers, 2004) and by categorizing its central aspects into declarative and procedural knowledge (Elferink-Gemser, Visscher, Richart & Lemmink, 2004; McPherson & Kernodle, 2003). In short, declarative knowledge includes knowledge of the rules and goals of the game (Williams & Davids, 1995) whereas procedural knowledge involves the selection of an appropriate action within the context of the game (McPherson, 1994). Said differently, knowing ‘what to do’ in a specific circumstance refers to declarative knowledge and ‘knowing how to do it’ and ‘doing it’ refers to procedural knowledge.

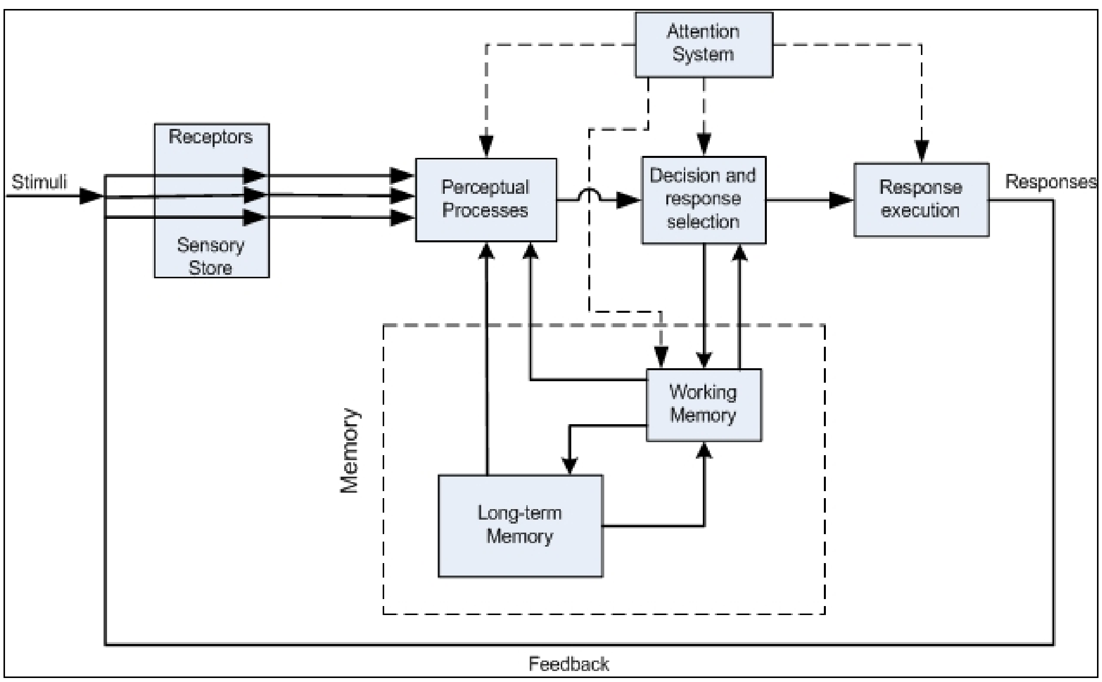

Figure 1. *A generic information-processing model* (Summers, 2004).

Looking at Figure 1, the stimulus identification phase of the process is represented by the sensory store and perceptual processes in the diagram. During this first stage, the athlete’s task is to determine whether information, referred to as the stimulus, has been presented and to identify it. In essence what happens during the stimulus identification phase is an analysis of environmental information, the assembly of the information into a unified whole and the detection of patterns formed by this unification (Schmidt & Wrisberg, 2004). The activities of the response-selection phase, shown in the centre of Figure 1, start once the stimulus identification phase has provided the athlete with enough information about the nature of the environment the athlete finds himself in. With this information at his/her disposal, the athlete must then decide on the most appropriate response for the given situation (Summers, 2004). Finally the response programming or response execution stage is set into motion once the athlete has decided on the movement to be made, by organizing the motor system into performing the desired action (Schmidt & Wrisberg, 2004) and executing the chosen action. The output or result of the response is then perpetually fed back into the information processing system, more often than not at an incredible speed, allowing the athlete to produce and perform a number of actions in a short period of time (Summers, 2004). As shown in Figure 1, there are other cognitive functions that influence the processing of information according to this model, most notably: attention, working memory and long-term memory (Summers, 2004), with other factors also found to influence the process including reaction time, anticipation, arousal and anxiety (Schmidt & Wrisberg, 2004).

Although the athlete might not always be consciously aware of the sequential mental processes that are operating in order to make a decision due to the sheer speed at which it occurs, the information processing approach has been applied with great success to the study of expert mental on-field performance (Tenenbaum, 2003). The process has been studied in controlled settings by isolating certain phases or aspects of the process, for example perceptual expertise (Williams & Ward, 2003), as well as being studied in natural situations with use of advanced technological devices (Abernethy, Farrow & Berry, 2003) and self-report studies (Elferink-Gemser, Visscher, Richart & Lemmink, 2004).

Having discussed the basic assumptions of the expert-novice paradigm, the naturalistic paradigm and the information processing approach, it would seem that the latter provides the best basis for studying the process and quality of decision-making in expert rugby players as it allows the researcher to get an in-depth look at what happens in between the identification of a stimulus and the execution of a chosen behavioural action. Although this is by no means an exhaustive discussion of the three approaches, it should provide a primary understanding of these perspectives and their approach to studying decision-making.

1.3 Justification, Aim and Objectives

From an extensive review of the literature, no evidence could be found that instruments have been developed to assess the quality of decisions made on the field by expert rugby players. Although a number of programs have been developed to increase the quality of on-field decisions (Vickers, Reeves, Chambers & Martell, 2004), no reliable criteria have been set in place to judge the effectiveness of these interventions. The development on an inventory by which the expert rugby player can judge the quality of his own on-field decision-making will make a practical contribution to the game, as it will allow players and coaches to assess decision-making quality over time, as well as to determine the effectiveness of training methods and interventions aimed at improving the quality level of on-field decision-making.

The aim of the research is to develop a valid and reliable inventory that can be used by expert rugby players to assess the quality of their own decision-making that takes place on the field. The inventory will make use of self-report information provided by each player after having played a match to present an individual score on the quality of decision-making for each player.

The objectives of the research are as follows:

a) To design an extended questionnaire that best represents the theoretical underpinnings of decision-making in natural environments.

b) To identify the items in the questionnaire which are the best indicators of high quality decision-making and dividing these items into components/factors that represent different aspects/phases of decision-making.

c) Making use of these factors and related items to construct an inventory that can be used to assess expert rugby players' level of decision-making through self-report.

1.4 THEORETICAL OR PARADIGMATIC POINT OF DEPARTURE

The theoretical point of departure for this research is the information processing approach, which makes the assumption that cognition consists of serial and non-overlapping processing stages that exist between a stimulus and a response (Wrisberg, 2001). With the use of flow diagrams, the flow of information is typically traced through three primary stages involving perceptual processes, decision-making and response selection, and response programming and execution. An attentional system in control of the selection of information sources is responsible for further processing and memory systems (long-term and working memory) for the storage of information are also part of most information processing models (Summers, 2004). The sequential stages of information processing were shown in Figure 1.

Although these processes cannot be directly observed, it is argued that there are two basic limitations to information processing that can be measured, namely the limitations of time and space (Keele, 1973). Reaction time (RT) and movement time measures are used to study the temporal aspects of information processing, while dual-task activities are used to measure space constraints (Summers, 2004). Reaction time has been shown to be a good indicator of the speed and effectiveness of decision-making (Schmidt & Wrisberg, 2004), especially in expert performers or athletes. This may be because elite performers possess (1) the ability to recognize important stimuli sooner, (2) a variety of appropriate responses ready for execution, and (3) the ability to react more rapidly than novices (Wrisberg, 2001). Figure 2 gives an illustration of how the stages of information processing might proceed in expert athletes having to make quick decisions under high levels of time pressure.

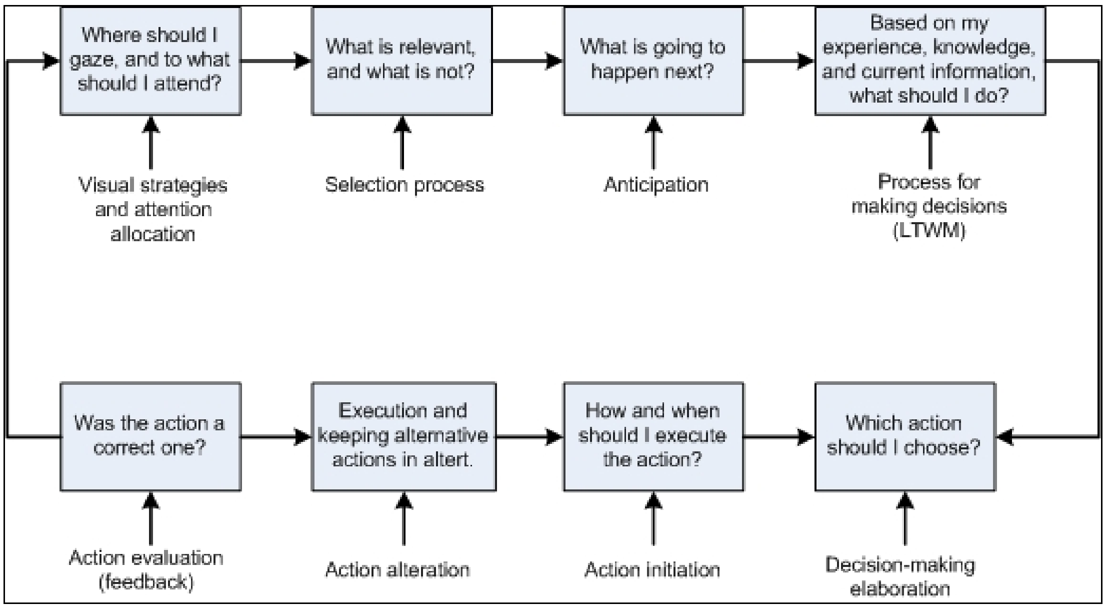

Figure 2. *Decision-making types and their corresponding cognitive components* (Tenenbaum, 2003).

According to Tenenbaum (2003), the most central aspects of quality on-line decision-making that need to be assessed in open-skills sport experts are (1) the visual strategies employed to search for relevant stimuli information in the dynamic environment, (2) the anticipatory mechanisms used in conjunction with working memory to predict what is going to happen next, and (3) the long-term memory structure that holds the declarative and procedural knowledge that has been acquired through years of on-field experience. The essence of the response selection or decision-making stage of information processing therefore lies in deciding which part of the environment to look at, predicting what is going to happen next and deciding on how to react to these anticipated changes. Thus, by focusing on these aspects it becomes possible to study and assess decision-making in dynamic, open-skill sport.

1.5 Proposed Research Methodology

1.5.1 Hypothesis

The hypothesis on which this research will be based will include the independent variables of either being a junior or senior level expert rugby player and the dependent variable of decision-making quality, based on visual search strategies, anticipation or working memory and selection of response.
The research hypotheses can be stated as follows:

> H_0: No difference exists in the self-reported quality of on-field decision-making, measured in terms of visual search strategies, anticipation guided by working memory and response selection, of senior level expert rugby players, compared to that of junior level expert rugby players.
>
> H_1: The self-reported quality of on-field decision-making, measured in terms of visual search strategies, anticipation guided by working memory and response selection, of senior level expert rugby players is significantly higher than that of junior level expert rugby players.

1.5.2 Research design

This study will take on the form of a one-group posttest-only quasi-experimental design, which involves making observations on only those persons that have undergone a treatment only after they have received it (Cook & Campbell, 1979). Although no direct treatment condition will be involved in conducting the study, one can consider the participant's rugby playing experience as the 'treatment-condition' they bring into the study, with their participation in the study being the post-test. The aim of the study is not to measure the impact or influence of any treatments, but is rather more exploratory in nature, as it is aimed at studying a subject that is relatively new and this type of design assists in the development of methods that can be useful for future, in-depth enquiry (Rubin & Babbie, 2001). This will be achieved with the use of a self-administered survey taking on the form of a factorial design, which will contribute to the uncovering of the complex sets of interrelationships present in the study of expert decision-making. This type of analytic survey design allows the researcher to approximate laboratory conditions, as it facilitates the selection of participants who already have the characteristics required by the study (Oppenheim, 2004). The factorial design further provides the opportunity of studying several experimental variables in combination, not only providing more information but also with greater confidence in the prediction of results (Tacq, 1997).

1.5.3 PARTICIPANTS

As the study is aimed at designing an inventory that can be used to measure the level of decision-making of expert rugby players, it would be best to involve such players when trying to establish the criteria it is measured against. Whitley (2003) refers to the selection of participants according to the goals of the research, as purposive sampling, with the researcher viewing each participant as a typical case of the population they belong to. The sample will be made up of around 85 under-19, under-21, Vodacom Cup and Super 14 players from the Blue Bulls Rugby Union (BBRU). The distinction between either being a junior or senior player is based on the fact of having played Vodacom Cup, international age-group world cup or Super 14 rugby, which is considered to be on a level above domestic age-group rugby. Therefore, those players from the sample that have played at least one Vodacom Cup, international age-group world cup or Super 14 game, will be considered to be senior players. These players can be regarded as being expert players, as they are professional rugby players, while most of them have been national champions over three of the last four years in their age-group competitions.

1.5.4 MEASUREMENT INSTRUMENT

A questionnaire consisting of 40 items, related to the key aspects of decision-making in open-skill sport environments, will be used to assess the self-reported levels of decision-making of the participant expert rugby players. Each item will be assigned a score ranging from 1 = very poor to 5 = excellent based on the self-rated on-field performance of the players. The questionnaire will be loosely based on an instrument used by Elferink-Gemser *et al.* (2004) to measure the decision-making quality of young expert field hockey and soccer players. The questionnaire will be adapted to include items that can be applied to an expert rugby context and it will be completed by around 85 expert rugby players. The items will be formulated to include all of the aspects considered to be of importance in consensus with expert rugby coaches, also associated with the BBRU. Items used to gather demographic information from the players in terms of their age, years of playing experience and playing position will also be included in the questionnaire. The aim of including this information in the analysis is to determine whether these factors have an influence on the quality of on-field decision-making.

As a result of the nature of the sample needed to complete the questionnaire, measures of test-retest reliability do not seem to be the best manner in which to assess the reliability of the items used for constructing the instrument. As the available sample is of a limited size and given the fact that results taken at different times in the year may vary as a result of extraneous variables, such as players taking part in different levels of competition during the season, it might not be beneficial to extend the assessment of players over a long period of time. In dealing with these challenges the most suited way to assess the reliability of the measurement instrument would seem to be by randomly assigning each of the participants into one of two groups, have them complete the item list and then compare the results obtained from each of the groups, by use of statistical techniques discussed under the section on data analysis. The reliability of the inventory can further be assessed by conducting subsequent split-half reliability evaluations in order to identify whether the inventory does in fact have internal consistency (Kerlinger, 1979).

Issues regarding the construct validity of the instrument will be dealt with by strictly adhering to the theory (Whitley, 2003) on the dimensions of high levels of decision-making in sporting contexts, as it is outlined by Tenenbaum (2003) when choosing and constructing items to be included in the initial item pool. Content and face validity will be addressed by involving some of the expert coaches of the BBRU in a discussion on the practical aspects of quality on-field decision-making they consider to be of importance to be included in the questionnaire. These coaches will also be involved in compiling the questionnaire, in an effort to ensure that the items included cover all of the major dimensions of decision-making in terms of practical on-field situations, as identified in the theory on procedural and declarative decision-making. Lastly, criterion validity will be assessed by comparing scores obtained in this study to the scores obtained by Elferink-Gemser et al. (2004) on similar items. This can be done as both studies are aimed at assessing the on-field decision-making of expert players, with the only difference being the sports in which they participate.

1.5.5 DATA COLLECTION PROCEDURES

The questionnaire will be administered to the players under controlled conditions at the facilities of the BBRU and - depending on the size of the facilities - it will be decided whether to divide the entire group of participants into smaller groupings. Each individual player will be required to complete a questionnaire after giving informed consent to participating in the study. The questionnaire will be made up primarily of items adapted from the study conducted by Elferink-Gemser *et al.* (2004). The items will be modified to be applicable to a rugby context, as the original items were designed to be used in soccer and field-hockey. Examples of these items will include statements such as “If my team receives the ball I know exactly what to do” and “During matches I look not only at the ball but also over the field”. Each statement will then be assigned a score, according to the players self-reported skill level in carrying out this action, as described above. The participants will further be instructed to answer each of the items in terms of their personal on-field performance and to try and answer as accurately and honestly as possible.

1.5.6 DATA ANALYSIS

As the study involves the development of a measurement scale, factor analysis, followed by a varimax rotation (Kerlinger, 1979) will be used to group items in the appropriate categories of dependent variables. The Cronbach alpha statistic will be used to check for consistency between sample groups, as well as the internal consistency of the inventory (Creswell, 2003). Descriptive statistics can also be utilized to compute the means and standard deviations of scores assigned to each item in the questionnaire. The methods applied should yield results that can be used to distinguish the most appropriate items to be included in the inventory, taking into account the most important aspects of high level decision-making in expert sport performance.

1.6 ETHICAL CONSIDERATIONS

Permission will be obtained from the Blue Bulls Rugby Union to involve their players in the study, as well as from the coaches of the respective teams that these players belong to. It is believed that this study will not have any negative physical, psychological or emotional consequences for the players involved and it will also not interfere with their training program, as testing times will be scheduled with the respective coaches.

As all of the players are over the age of 18 years, they will be asked to give informed consent before any testing takes place. All the necessary measures will be put in place to ensure that the results will be confidential, as the only personal information needed for the study are that of years of playing experience, age and playing position. The results of individuals will not be made available to anybody other than the researcher and can therefore not be used to discriminate against any of the players. The raw results of the study will be kept by the researcher in a safe place.

1.7 DISSEMINATION OF RESEARCH RESULTS

As the study is aimed at the development of a preliminary decision-making inventory in expert rugby players it may be used as a basis for determining the effects of intervention programs aimed at the improvement of decision-making in rugby. The inventory can be used by coaches and players functioning at the expert level, but further refinement would be needed for using the inventory on less-skilled levels.

2. LITERATURE REVIEW

2.1 INTRODUCTION

The domain of sport offers an incredibly rich and diverse 'natural laboratory' in which to study cognition and its links to motor performance (Abernethy, Maxwell, Jackson & Masters, 2007). Sports constantly challenge the limits of human physical and mental capability in dynamic situations characterized by extreme time constraints, changing goals as well as perceptual and behavioural complexity (Schmidt & Wrisberg, 2004). Expert performers in sport have been studied extensively since the 1950s, with early assumptions being that these performers' posses innate individual differences in terms of their optometric and mental processing abilities (Helsen & Starkes, 1999). This approach to studying the individual differences in the 'hardware' of expert performers has tended to emphasize characteristics like enhanced hand-eye coordination and movement speed as contributing to success in sport (Rodionov, 1978). This approach remains strong to this day, as seen in research conducted by Dr Annette Lotter in *Genetic Brain Profiling,* a technique aimed at predicting how rugby players will react mentally under conditions of stress and fatigue as a result of hemispherical dominance in the nervous system (Colquhoun, 2007). What these approaches have in common is the assumption that expert athletic performers are born with superior mental and physical abilities that will enable them to excel in their sport of choice.

In addition to these findings, a growing body of research evidence indicates that expert performer's posses advanced domain-specific perceptual abilities and functional knowledge, referred to as 'software', developed over many years of sporting experience (Abernethy, 1999a; Williams, Davids & Williams, 1999). This approach is focused more on the acquired cognitive capabilities that enable the athlete to successfully function in a sporting context, rather than on the in-born, physical capabilities they might posses. The study of cognitive functioning in expert athletes, as opposed to novices, has received a lot of attention over the last few years, with studies focusing on skill-acquisition (Handford, Davids, Bennet & Button, 1997), perceptual-cognitive expertise (Williams & Ericsson, 2005), anticipation, concentration, short-term and long-term memory (Singer, Murphy & Tennant, 1993), reaction time (Ericsson, Patel & Kintsch, 2000), motor performance and experience (Summers, 2004). An aspect central to all of these studies has been the assumption that expert performance in sports result from many years of experience of playing the game, which places it in somewhat of a contrasting position to the individual differences approach referred to above.

The on-field/court decision-making of expert athletes is thought to be one of the most important aspects studied by the latter approach, as it involves number of decision agents (coaches and players), tasks (play-calling, ball allocation) and contexts (during play or timeouts; Johnson, 2006), as well as most of the cognitive functions mentioned above (Abernethy *et al.,* 2007). The on-field decision-making of expert athletes has been researched quite extensively in a number of sporting codes, including basketball (Raab, 2001), field hockey (Williams, Ward & Chapman, 2002) and soccer (Ward, Williams & Ericsson, 2003), while a growing recognition of its importance also seems to be taking place in rugby unions. In recent times, calls have been made for more intelligent rugby players (Ross, 2001), with the process of decision-making regarded as one of the most important aspects of successful on-field performance which may promote such intelligence (Tavares, 1997). In a recent article published in the *South African Rugby Magazine* (Keohane, 2006), several experienced rugby coaches and other experts referred directly to the lack of on-field thinking that seems to be taking place in South Africa's top players, with most of these experts being of the opinion that players rely too heavily on game plans and playing patterns, resulting in their play becoming predictable and ineffective very quickly. Studies and training programs aimed at measuring and improving the on-field decision-making of expert rugby players are therefore very topical, as these aspects of performance have, until very recently, received little attention (Johnson, 2006).

A number of approaches have been followed in studying the cognitive functioning and decision-making of expert sports men and women in on-field, sport related situations. Each of these approaches emphasize different aspects of expert decision-making under time pressure and use different measurement techniques to assess the quality of decision-making made in natural situations. Before discussing each of these approaches, a brief overview will be given of the key concepts referred to in these approaches, as well as their theoretical assumptions as they pertain to the topic under discussion.

2.2 OVERVIEW OF KEY CONCEPTS

Rugby union can be categorized as an invasive type of game, as it involves opposing teams competing on the same field of action in terms of ball possession and field position. A characteristic of rugby players is that they constantly need to adapt to their opposition by adapting to new roles within play (offensive or defensive), new play configurations and to the circulation of the ball (Grèhaigne & Godbout, 1995). Two types of skill are required to perform within this environment, namely closed- and open-skills. Closed skills are self-paced and are executed within a stable environment that does not change during the performance, while open-skills are externally paced and performed in dynamic environments that vary in terms of speed, direction, and levels of uncertainty (Magill, 2001). Although closed-skills are used in some aspects of rugby, for example going through your preparation technique while kicking at goal, the majority of decisions made are dependent on open-skills applied within the dynamic game context.

Decision-making can be defined in a number of ways depending on the theoretical framework used to study the phenomenon. Normative or rational models of decision-making emphasize the comprehensive gathering of information and sequential processing thereof, whereby the decision-maker can come to a decision, after considering all of the possible options, that holds the most utility or value (Maule & Edland, 1997). Decision-making in dynamic situations differs quite substantially from the way it is done in static situations. Although these definitions still include the gathering and processing of environmental information, the information gathered is mostly incomplete, the goals are ambiguous and multiple options cannot be considered because of the time pressure inherent in the situation (Abernethy *et al.,* 2007). Time pressure can play a large part in affecting the on-field decision-making of expert rugby players, as most decisions have to be made and the appropriate actions completed in times ranging from less than a second to no more than five seconds. Speeded decision processing is therefore very important for the open-skill performer who must quickly select a response that meets the demands of changing environmental conditions (Wrisberg, 2001).

Three particular approaches to studying the cognitions and decision-making of experts in natural environments seem to dominate the literature, namely the *Expert-Novice paradigm*, the *Naturalistic Decision-Making paradigm* (NDM), and the *Information Processing approach.* Before giving an overview of each of these approaches, their findings and the methods used to study decision-making in expert athletes and experts from other field, a brief discussion will be given of the main theoretical assumptions held by these approaches.

2.3 OVERVIEW OF THEORETICAL ASSUMPTIONS

Although the approaches mentioned above were not originally designed for application in a sporting context - with the exception of the expert-novice paradigm - they do share some important aspects that make their application within this context worthwhile. Firstly, these approaches differ from what are known as rational or normative decision-making models (Lehto, 1997), which have primarily focused on how people should make decisions according to some optimal framework, characterized by sufficient time and information (Wickens & Hollands, 2000). These types of models are deterministic in nature, in that they assume that the option with the highest expected utility will always be selected (Johnson, 2006). The expert-novice paradigm, the naturalistic decision-making (NDM) paradigm, and information processing approach, on the other hand, are known as probabilistic or dynamic models, as they look to incorporate the variance of human behaviour. They are further characterized as investigating decision-making in settings that are marked by ill-defined goals, shifting conditions, high levels of uncertainty, time pressure, ambiguous or incomplete information and multiple players (Pliske & Klein, 2003). Time pressure, as previously mentioned, is particularly important in the study of decision-making in expert rugby players, as these players seldom have more than five seconds to make a decision. Taking all of these factors into account, it would seems that these probabilistic models are much more appropriate for studying decision-making in dynamic environments like a rugby match, than are the models used to predict behaviour in well-structured situations in a deterministic, linear fashion.

High levels of experience in the natural decision-making situations is a precondition for studying decision-making according to these probabilistic approaches, with Ericsson (1996) finding that, in most cases, ten years of deliberate practice being required for an individual to achieve a level of motor and cognitive expertise in sport. Sport scientists have however experienced difficulty in producing empirical evidence for Ericsson's proposal, with Salmela (1999) suggesting that this lack of success may be due to qualitative differences in the nature of competitive sports. Considering that players as young as 20 years have recently represented the national rugby team of South Africa - the Springboks - the ten years of deliberate practice criteria proposed by Ericsson (1996) seems to be of limited value.

Finally, it must be noted that to date, no consensus has been reached on what high quality or good decision-making entails (Shanteau, 1992). One approach has been to say that 'good' decisions are those that produce 'good' outcomes (Klein, 1996) entailing that the decision-maker can only judge his/her decision quality in retrospect of the outcomes. This approach isn't entirely satisfactory, as the outcomes of decisions are more often than not reliant on other players in a team, enhancing the possibility than good initial decisions can have 'bad' outcomes as a result of subsequent on-field actions of other players, placing the outcome beyond the control of the decision-maker. Another approach to decision quality is based on the concept of expertise, whereby a decision is judged as being good when it can be assumed that an expert in the field would have done the same in a similar situation (Baker, Côte & Abernethy, 2003). The problem is that experts do not always make better decisions than novices (Shanteau, 1992), often resulting in highly skilled players making elementary on-field mistakes. A final approach to judging the quality of on-field decisions proposed by Schmidt and Wrisberg (2004) is to judge decisions according to the advantage they produce over a player's opponent. If a decision, regardless of the execution of the accompanying action, can be judged to produce an advantage over one's opponent in most situations it is employed in, then it can be regarded as being a high quality decision. For the purpose of this study, the approach will be adapted that, when all three of these characteristics converge it becomes easier to discriminate good from bad decision-making.

2.4 THEORETICAL APPROACHES TO STUDYING DECISION-MAKING IN SPORT

Having discussed the basic concepts of central importance to these probabilistic models of decision-making, namely that of experts making decisions in dynamic situations under extreme levels of time pressure, the remainder of this section will be used to discuss each of these approaches, their methods and main findings as they incorporate these concepts and their influence on decision-making in sport.

2.4.1 THE EXPERT-NOVICE PARADIGM

The most direct approach to examining differences in the skill level of individuals is to compare the competence of beginners, average performers and experts on various characteristics of perceptual-motor performance (Wrisberg, 2001). As already mentioned, the performance advantage enjoyed by experts is due to domain-specific cognitive, perceptual and motor capabilities developed over many years of sporting experience (Abernethy, 1999a) and considering that this approach was developed with the sporting context firmly in mind (Chase & Simon, 1979) some very interesting findings have been made. Studies of this nature have typically involved the isolation and comparison of specific perceptual processing capabilities, sport specific knowledge, or the mechanical efficiency of expert athletes and non-expert athletes (Wrisberg, 2001).

To date, no attempt has been made to incorporate all of the findings of the expert-novice paradigm into a coherent model of expert sporting skill and decision-making as a process, primarily as a result of the *deliberate practice* theoretical framework's inability to explain and predict expertise in the motor domain (Abernethy, Farrow & Berry, 2003), although findings obtained from these studies do shed some light on the specific cognitive skills possessed by expert sportsmen and women. For example, it has been found that more skilled athletes encode/retrieve game structure information differently and/or more quickly (Christensen & Glencross, 1993), use more efficient visual search strategies (Abernethy, 1991) and they also selectively attend to different kinds of information in the sports environment (Tenenbaum & Summers, 1996). Furthermore, experts are characterized by superior pattern recognition and anticipation skills (Abernethy, Farrow & Berry, 2003), superior decision-making skills, especially in terms of declarative and procedural knowledge (McPherson & Kernodle, 2003), as well as superior movement execution skills (Janelle & Hillman, 2003). Although this approach is closely aligned with the information processing approach, the emphasis is much more on discovering differences in specific cognitive aspects, such as information encoding, recognition, signal detection and anticipation (Williams & Ericsson, 2005), than on integrating the results into a comprehensive model. The best way to explain the research done in the expert-novice paradigm is to look at some of the methods used to isolate specific aspects of cognitive functioning and this will be done in the following section.

2.4.1.1 METHODOLOGY OF THE EXPERT-NOVICE PARADIGM

An example of a single cognitive aspect that has been studied extensively through use of the expert-novice paradigm is anticipation (Williams, Davids & Williams, 1999). From this perspective, research has primarily focused on the relationship between anticipation ('what is going to happen next?') and advanced cue utilization, which can be defined as an athlete's ability to make accurate predictions based on contextual information available early in an action sequence (Abernethy, 1987a). Advanced cue usage in sport has been examined according to a number of techniques, which can be logically divided into laboratory- and field-based approaches (Williams, Davids & Williams, 1999). Typical laboratory-based designs have used film to simulate the visual display that athletes are confronted with during play, with the most popular techniques being the film occlusion and reaction time approaches (Horn, Williams & Scott, 2002). On the other hand, field-based approaches have strived to be more ecological by measuring on-field/court performance directly using techniques such as high-speed film analysis and liquid crystal occlusion glasses (Williams, Davids & Williams, 1999).

Laboratory-based approaches

The temporal occlusion approach involves filming a visual display, like the serve in tennis, from the point of view of the competitor. The film is then edited at different point in the action to provide the subject with a varying extent of situational information. The film is then played back repeatedly to the subject with information missing from different segments in the execution of the action (the serve), with the participant having to predict the end result of the action sequence observed (Williams, Davids & Williams, 1999). Using the example of the tennis serve, the film is edited to exclude the presentation of the sequence before, at and after impact with the ball, with the participant then having to predict the direction and flight of the ball off the opponent's racket. The subject is then asked to indicate where the ball is going, allowing the researchers to measure the accuracy of the prediction, as well as being provided with information as to which part of the action sequence provides the most valuable information in terms of accurate anticipation. Results from a study conducted by Jones and Miles (1978) found that expert players were best able to predict where the ball was going to land using information available prior to ball/racket impact in the tennis serve. These results illustrate that expert performers rely more on information provided by the position of the opponent's body rather than ball flight, which provides the expert that fraction of a second more to get into position than the novice player. The expert's ability to use advance visual cues has been proven in sports such as field hockey (Starkes, 1987) and cricket (Abernethy & Russel, 1984).

Event occlusion follows similar techniques, but in this technique a series of photos are taken of the action sequence of the tennis serve before and after impact. The pictures are then shown to the subject individually, whereby he/she should then again predict where the ball is heading (Williams, Davids & Williams, 1999). This technique allows the researcher to find out exactly what part of the action sequence holds the most information for the expert observer in terms of anticipating where the ball is going, with results again showing that most information is extracted before impact is made with the ball (Abernethy, 1991). Again this allows the expert to get into the correct counteractive position more quickly, which can lead to a significant advantage over one's opponent.

Finally, in the reaction time approach, subjects also view a filmed display and are required to provide the correct reaction when they feel that they have gathered enough information about the situation (Williams, Davids & Williams, 1999). For example in cricket, expert and novice batsmen view a filmed display of a bowler running up and bowling at them. The subject is then required to imitate playing a shot and the accuracy of the shot is then assessed according to where the ball landed. When the batsmen makes his first movement the video is paused, giving the researcher a clear indication of when in the sequence sufficient information for shot selection had been gathered (Abernethy & Russel, 1984). These laboratory-based results have led to the conclusion that expert athletes encode and retrieve game information differently and more quickly than novices (Wrisberg, 2001).

Field-based approaches

Laboratory-based approaches have been criticized for having low ecological validity, as a result of the two-dimensional, scaled down images shown to the participants. As a reaction to these criticisms, two primary techniques have been developed to study the anticipation techniques of expert athletes in natural game situations, namely high-speed film analysis and visual occlusion techniques (Williams, Davids & Williams, 1999). High-speed film analysis involves filming the actual play of an expert athlete taking part in a real match at a rate of 100 frames per second or higher, with the aim of determining the latency between the presentation of new visual stimuli (the opponent moving to hit the ball) and initiation of the counteractive body movement by the subject (Abernethy *et al.,* 2007). The field-based visual occlusion technique usually involves placing a helmet on the head of the subject that is equipped with an electronic shutter than can be triggered by the researcher next to the field or court. At different times during the action sequence of the opponent can the researcher trigger the shutter to 'blind' the subject for a short period of time. The accuracy of the subject's anticipatory movement is then assessed by judging whether he/she moved in the correct direction and at the correct speed to counteract the play made by the opponent (Beilock & Carr, 2004). The results obtained from studies using these techniques have tended to replicate the findings of the laboratory-based approaches, in that expert athletes tend to make their anticipatory movements much earlier than less-skilled athletes (Christensen & Glencross, 1993).

These results correspond to the notion mentioned above that expert sport performers are superior in most, if not all, of the cognitive functions involved in sport performance compared to novices. Techniques similar to those discussed above are used to study other cognitive aspects from the expert-novice approach such as visual search strategies, attention, knowledge structures and decision-making (Abernethy *et al.,* 2007). Viewed separately, these results have led to some important insights regarding the perceptual-cognitive and motor skills of expert athletes, but the failure to integrate these results deals some damage to the approach as a whole. This failure towards integration is understandable, as the in-depth study of these functions relies on the isolation of each aspect of cognitive functioning, with subsequent measurement of each aspect relying on the use of expensive technological techniques. This leads to an increased difficulty in describing and explaining the processes that occur between the recognition and encoding of visual information to the selection of an appropriate behavioural response or action, being the main characteristics of decision-making.

2.4.2 THE NATURALISTIC DECISION-MAKING PARADIGM

Naturalistic decision-making (NDM) can be defined as the study of how people use their experience to make decisions in field settings (Zsambok & Klein, 1997). The most important element of this definition is the emphasis on experience, as NDM researchers believe that many important decisions are made by people with domain experience, making it important to study how people use their experience to make decisions (Pliske & Klein, 2003). A number of conditions have been used to describe decision-making in natural settings according to the NDM-perspective, with the most important aspects including time pressure, uncertainty, dynamic conditions, ill-defined or multiple goals, feedback loops, multiple players and high stakes associated with particular decisions being made (Orasanu & Connolly, 1993). This perspective fits in well into the class of dynamic decision-making models, as it is not aimed at predicting decision-making behaviour, but rather at understanding or describing how it takes place within a naturally occurring environment.

The NDM perspective has been predominantly used in studies of human factors and ergonomics, as it was originally designed to study how people in the military, aviation and other applied settings perform their jobs and make 'on-line' decisions (Pliske & Klein, 2003). All of these natural settings are characterized by decision-making occurring under situations of stress, time pressure and uncertainty. Specific studies have looked at the decision-making of, for example, navy command and control specialists (Wohl, 1981), fire-ground commanders who supervise and command teams of fire fighters (Klein, Calderwood & Clinton-Cirocco, 1989), physicians and surgeons (Dawson, Connors & Speroff, 1993), military pilots and weather forecasters (Pliske, Crandall & Klein, 2004). Although very applicable, this perspective has not been used to study the on-field decision-making of expert athletes competing in open-skill sports. The main reason for this might be the fact that NDM is primarily aimed at describing the conscious processes that lead to decisions being made by experts in the field (Sieck & Klein, 2007), rather than finding ways to uncover the underlying processes that operate in the making of a decision.

Although models have been developed to describe the components of expert decision-makers (Klein, 1998), the methods employed in the NDM perspective have been criticized for using primarily verbal reports in decision research, with the argument being that experts are conscious of the products of their mental processes but not of the decision processes themselves (Sieck & Klein, 2007) that underlie these conscious mental processes. Researchers working within the NDM perspective have, however, reacted against these criticisms by stating that the primary aim of the approach is that of describing the process of expert decision-making in natural, time pressure situations and not the testing of hypotheses (Pliske & Klein, 2003). The remainder of this section will be used to give an overview of the naturalistic decision-making models as well as the dominant techniques used to gather descriptive information from decision-making experts.

2.4.2.1 THE RECOGNITION-PRIMED DECISION MODEL

The model most closely associated with the naturalistic decision-making paradigm is the *Recognition-Primed Decision* (RDP) model proposed by Klein, Calderwood and Clinton-Cirocco (1986). Originally the model was developed to explain how fire-ground commanders used their experience to select a course of action without having to compare different options (Pliske & Klein, 2003). This model can be placed in direct contrast with most normative decision-making models that propose the sequential processing and comparison of different options before a final decision is made. How can anyone then make the correct decision if he/she does not consider all of the possible options? Interestingly Klein *et al*. (1986) found that fire-ground commanders use their experience to quickly size up a situation and then select the typical action to take in the situation. Therefore, the making of comparisons between possible actions is substituted by a process of accessing the long-term memory to find examples of similar previous experiences and to make use of tactics that had worked in the past. These researchers also found that the fire-ground commanders would then simulate the chosen course of action in their minds to 'see' if it would work in the specific situation. If the initial course of action had some weak points it would be discarded and another typical situation would be searched for in long-term memory, repeating the process until they found a workable option (Klein *et al.,* 1986). Figure 3 gives an illustration of the RDP model as it includes three types of decision-cases faced by decision-makers in natural, time-pressure situations.

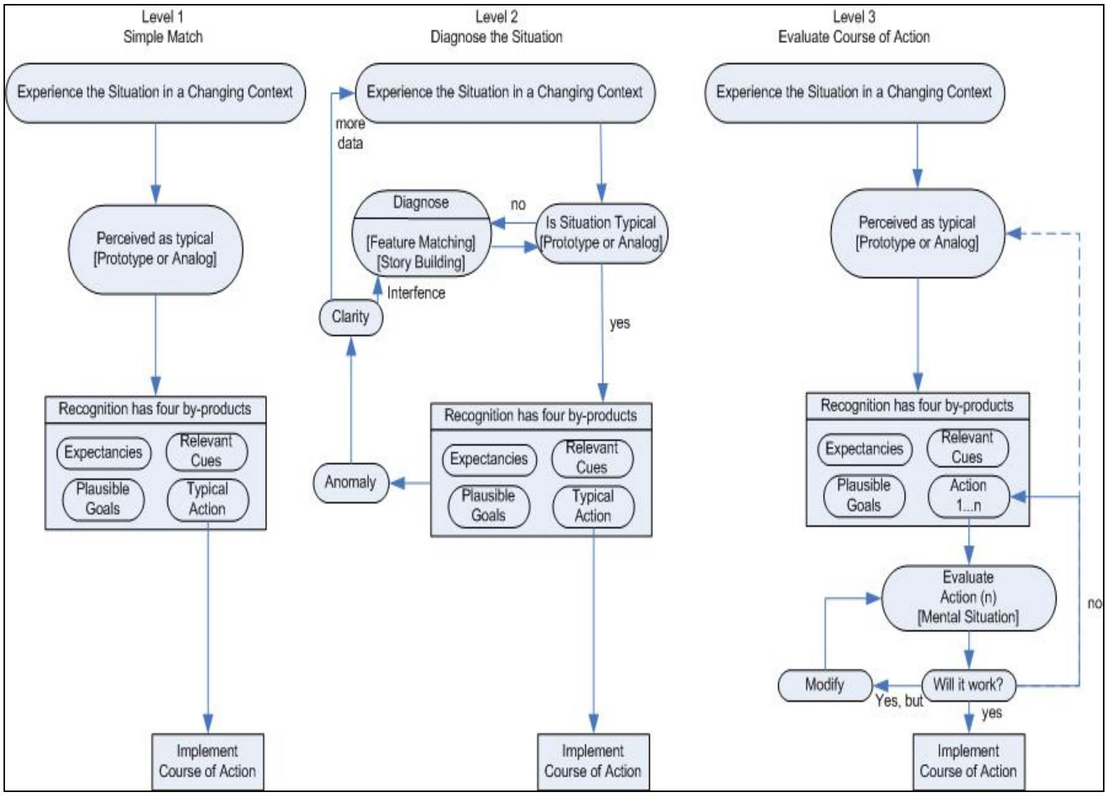

Figure 3. *The Recognition-Primed Decision (RDP) model*
(Pliske & Klein, 2003).

The simplest type of case, known as a simple match, is shown on the left-hand side of the model. In a simple match situation the decision-maker sizes up a situation, forms expectancies about what is going to happen next, determines the cues that are most relevant, recognizes the reasonable goals to pursue in the situation, recognizes a typical reaction and carries it out (Klein *et al.,* 1986). This process can be considered to be a decision, as it is quite possible that less experienced individuals could have chosen a different course of action seeing than it is reasonable to assume that a number of possible courses of action exist within each situation. The second panel of Figure 3 shows a more difficult type of case in which the decision-maker is not entirely sure about the nature of the situation. Some unexpected events might occur during the situation or it might not be possible to view or get information on all of the important aspects of the situation. Pliske and Klein (2003) state that in situations like these, it is important for the decision-maker to deliberate about what is going on and to make a conscious effort of finding causal links to the observed events in order to explain their occurrence. Diagnostic strategies are important in cases like this, with the most common diagnostic strategies being feature matching and story building. These strategies essentially involve a more thorough identification of the situation as typical and a more in-depth simulation of the chosen course of action (Klein *et al.*, 1986). Finally, the third panel involves the same process as in the other two, with the exception that shortcomings in the mentally simulated course of action can be revised or modified to be more effective (Pliske & Klein, 2003).

In its simplest form, the recognition-primed decision (RDP) model could be used to explain the decision-making strategies of experienced rugby players as they should have access to a large ‘database’ of previous experiences out of which they can recognize on-field situations as being typical or not. When the situation is recognized as being a non-typical problem of extreme time-pressure, it might prevent the player from searching for alternative courses of action or revising the initially preferred action. Although the model was developed to describe decision-making strategies under conditions of time-pressure, it might not be all that useful when the expert has less than five seconds to make a decision.

2.4.2.2 METHODOLOGY OF THE NATURALISTIC DECISION-MAKING PARADIGM

As stated earlier, the naturalistic decision-making paradigm is very much aimed at developing strategies for improving the decision-making of experts in natural situations. In order to do this, the NDM perspective primarily makes use of two methods for studying the conscious cognitive processes at work when courses of action are chosen under conditions of high stress and time-pressure, namely cognitive task analysis (CTA) and simulations.

Cognitive task analysis (CTA)

NDM researchers use CTA methods to describe the cognitive skills needed to perform a task adeptly, or said differently, they explore the cognitive processes that underlie the behavioural components of a job (Pliske & Klein, 2003). CTA typically involves doing in-depth interviews with experts about retrospective accounts of incidents they took part in, with the aim of calling forth information on the knowledge, thought processes and goal structures underlying the observable performance of deciding on the most appropriate course of action taken (Sieck & Klein, 2007).

The CTA is conducted according to a number of stages or ‘sweeps’ that allows the researcher to analyze the cognitive tasks and functions at work when critical decisions are being made. The first sweep involves incident identification and selection, whereby the expert is asked to think of a situation in which his/her expert skills were tested to their maximum capacity. The thinking behind this type of knowledge elicitation is that it will help the expert to identify cases that are non-routine, challenging and difficult. The expert is then asked to give an account the entire situation as they remember it, as well as to make mention of what they were thinking at different times of the incident. During the second sweep, the expert goes back over the incident with the aim of verifying the account and providing structure to it by recalling the exact sequence in which certain actions were taken. The third sweep is aimed at progressively deepening the story, by going over key moments in the incident and by asking the expert specific questions regarding the assessment of the situation and the basis of the assessment, expectations about how the situation might evolve, the goals considered, and the options evaluated and chosen. Finally, the fourth sweep involves asking "What if?" questions about certain key moments in the incident. This allows the researcher to find out which alternative plans of action were considered and what would have been done differently had certain aspects of the situation drastically changed (Sieck & Klein, 2007). This interview method allows the researcher to get inside the mind of the expert and to find out exactly what they were thinking at specific times during the incident, which stimuli they considered as being of greatest importance and why they decided to do what they did.

Simulations

NDM researchers also use simulations to study the decision-making strategies of people in work settings. According to Woods (1993) simulations are the best way to study decision-making in natural environments, as researchers can achieve control over cues and can collect a variety of both quantitative and qualitative data. For conducting studies of this nature, simulations have to be as realistic as possible to be relevant to the expert decision-maker. The task has to engage the expertise of the experienced decision-maker, which makes it more likely that the results of the study will be applicable to the field setting (Pliske & Klein, 2003). If one were to conduct a study with the use of simulations in order to describe the decision-making strategies of expert rugby players, the simulations would have to be as close to a real-match environment as possible. This could however place the athletes in danger of sustaining injuries as it would increase their already high physical workload quite substantially.

Although these methods have been criticized for using too small sample sizes and for relying on subjective self-report information, they have been used in the design and development of technological and training solutions that have led to significant increases in the level of on-line decision-making of experts in their natural work environments (Hollnagel, 2002). It must be noted that, although these methods make it difficult to construct theories and measure them precisely, the contribution of the naturalistic decision-making paradigm seems to lie in the practical improvements it makes in the level of decision-making of experts in critical situations where second chances are, most likely, a luxury they cannot afford.

2.4.3 THE INFORMATION PROCESSING APPROACH

Developed in the 1960's in a reaction against the inability of behaviourism to explain higher-order mental processes, the information processing approach can be conceptualized as consisting of three distinct stages in information processing, namely the stimulus identification, response selection and response programming stages (Schmidt & Wrisberg, 2004). Although not originally designed for use in sporting contexts, the information processing approach has been applied with great effect in studying the decision-making and other cognitive functions of expert performers in sport in its original form (shown in Figure 2; Summers, 2004) and by categorizing its central aspects into declarative and procedural knowledge (Elferink-Gemser, Visscher, Richart & Lemmink, 2004; McPherson & Kernodle, 2003). In short, declarative knowledge includes knowledge of the rules and goals of the game (Williams & Davids, 1995) whereas procedural knowledge involves the selection of an appropriate action within the context of the game (McPherson, 1994). Said differently, knowing 'what to do' in a specific circumstance refers to declarative knowledge and 'knowing how to do it' and 'doing it' refers to procedural knowledge.

Looking at Figure 4 below, the stimulus identification phase of the process is represented by the sensory store and perceptual processes in the diagram. During this first stage, the athlete's task is to determine whether information, referred to as the stimulus, has been presented and to identify it. In essence what happens during the stimulus identification phase is an analysis of environmental information, the assembly of the information into a unified whole and the detection of patterns formed by this unification (Schmidt & Wrisberg, 2004). The activities of the response-selection phase, shown in the centre of Figure 4, start once the stimulus identification phase has provided the athlete with enough information about the nature of the environment. With this information at his/her disposal, the athlete must then decide on the most appropriate response for the given situation (Summers, 2004).

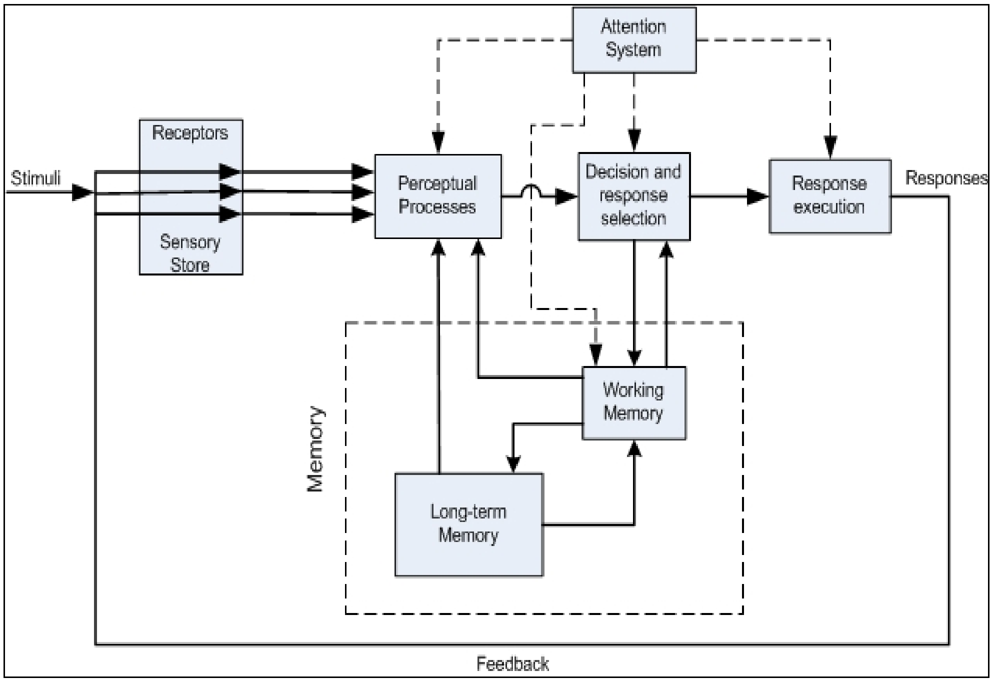

Figure 4. *A generic information-processing model*
(Summers, 2004).

Finally the response programming or response execution stage is set into motion once the athlete has decided on the movement to be made, by organizing the motor system into performing the desired action (Schmidt & Wrisberg, 2004) and executing the chosen action. The output or result of the response is then perpetually fed back into the information processing system, more often than not at a very high speed, allowing the athlete to produce and perform a number of actions in a short period of time (Summers, 2004). As shown in Figure 4, there are other cognitive functions that influence the processing of information according to this model, most notably attention, working memory and long-term memory (Summers, 2004), with other factors also found to influence the process including reaction time, anticipation, arousal and anxiety (Schmidt & Wrisberg, 2004).

2.4.3.1 Methodology of the Information Processing Approach and integration of results

While the athlete might not always be consciously aware of the sequential mental processes that are operating in order to make a decision because of the sheer speed by which it occurs, the information processing approach has been applied with great success to the study of expert mental, on-field performance (Tenenbaum, 2003). Historically, the information processing approach has prompted extensive research into the factors that influence motor skill learning, such as the influence of practice sessions, but sadly this work is of limited application to the study of the acquisition, development and usage of sport skills. To a large extent this was due to the adoption of research paradigms from mainstream experimental psychology that emphasizes firstly, carefully controlled laboratory experiments involving novel tasks and secondly, large numbers of participants to control for individual differences in past learning experiences (Summers, 2004). To overcome the limitations of the laboratory-based approach to expert skill development and application some cognitive psychologists began studying expert athletes in real-life situations. This gave rise to the expert-novice paradigm discussed above, whereby information processing has been studied in natural situations with use of advanced technological devices (Abernethy, Farrow & Berry, 2003), as well as in controlled settings by isolating certain phases or aspects of the process, for example perceptual expertise (Williams & Ward, 2003) and by the use of self-report studies (Elferink-Gemser, Visscher, Richart & Lemmink, 2004). It was noted earlier that the information processing approach and the expert-novice approach have much in common with regards to the cognitions they study and the methods used to study these phenomena. The major distinction between these approaches, however, is the extent to which the information processing approach has succeeded in integrating the results into a coherent system or process. Before looking at an example of how these results have been integrated into a coherent model that seeks to illustrate the cognitive advantages that expert have over novices in on-field decision-making, there will first be looked at some of the important aspects that underlie this model, namely the role of declarative and procedural knowledge.

Declarative and procedural knowledge: Anderson’s ACT theory

Anderson’s Active Control of Thought (ACT) theory attempts to explain how the superior knowledge base of experts is acquired and used in sports performance. Anderson (1983) suggest that human cognition is based on a number of condition-action links called products, that are responsible for initiating the appropriate actions under specific external conditions. If the condition specifies some sensory pattern (cross-defenders coming from the right) then the production initiates the appropriate response (running towards the left or breaking inside at the correct moment). A production has also been termed as an ‘IF…THEN…DO’ statement, with the appropriate action relying on the correct identification of the external conditions (Williams, Davids & Williams, 1999). An ACT production system consists of three different memories, namely declarative, production/procedural and working, shown in Figure 5. As noted earlier, declarative memory consists of information on ‘what to do’, whereas procedural memory contains knowledge regarding ‘how to do’ something.

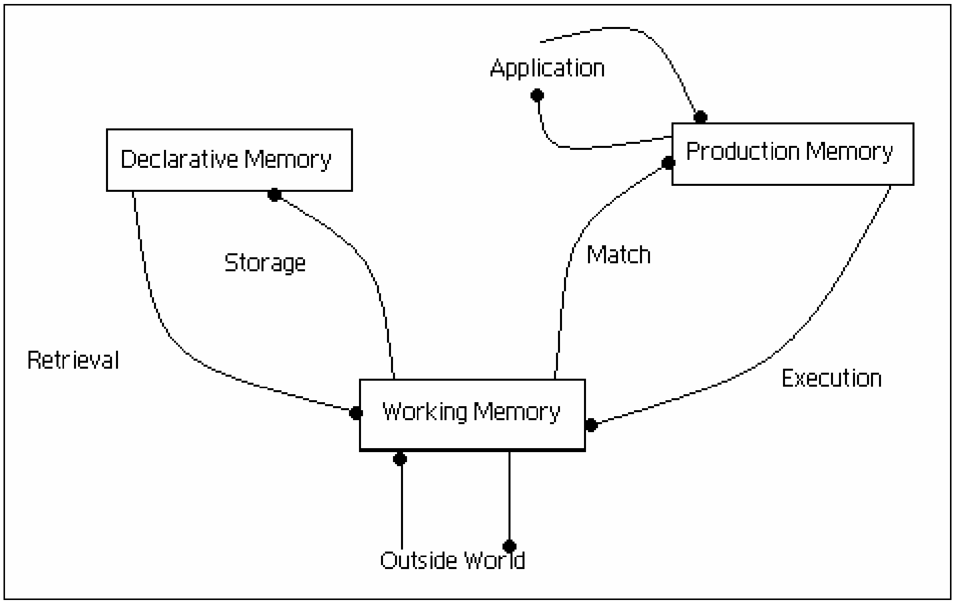

Figure 5. *The ACT production system framewor*k
(Anderson, 1983).

As learning progresses through increased levels of experience, declarative knowledge is said to be converted into procedural knowledge that captures the instructions of performing a task at hand (e.g. a novice learning to kick off his left foot) in a new form (Anderson, 1983). With more experience of performing the task (kicking off the left foot) the novice becomes an expert, as he no longer has to concentrate on the movement of his body and technique ('what to do'), as the information is converted into procedural knowledge as he becomes accustomed to the technique ('how to do it'). Unlike declarative knowledge, procedural knowledge does not require the active maintenance of each step of task execution in working memory (Beilock & Carr, 2004), which frees up a lot of attention that can rather be used on what to do, than on how to do it. Therefore, through experience the expert builds up a large repertoire of 'how to' information, resulting in these actions becoming more and more automatic each time they are reproduced. This allows the expert to allocate all of his/her attention to the dynamics taking place on the field, resulting in much more mental resources being allocated to what to do on the field, than to how it should be done.

2.4.4 A MULTI-FACETED SCHEME OF DECISION-MAKING IN SPORT

Incorporating results from studies examining the areas of expert cognitive functioning, Tenenbaum (2003) constructed a multi-faceted scheme for studying the on-field decision-making of expert athletes in sport, shown below in Figure 6 A comprehensive discussion of all the studies from which the results were taken to construct this conceptual scheme is beyond the scope of this chapter and therefore reference will only be made to the most central aspects of the model for describing the workings of the scheme.

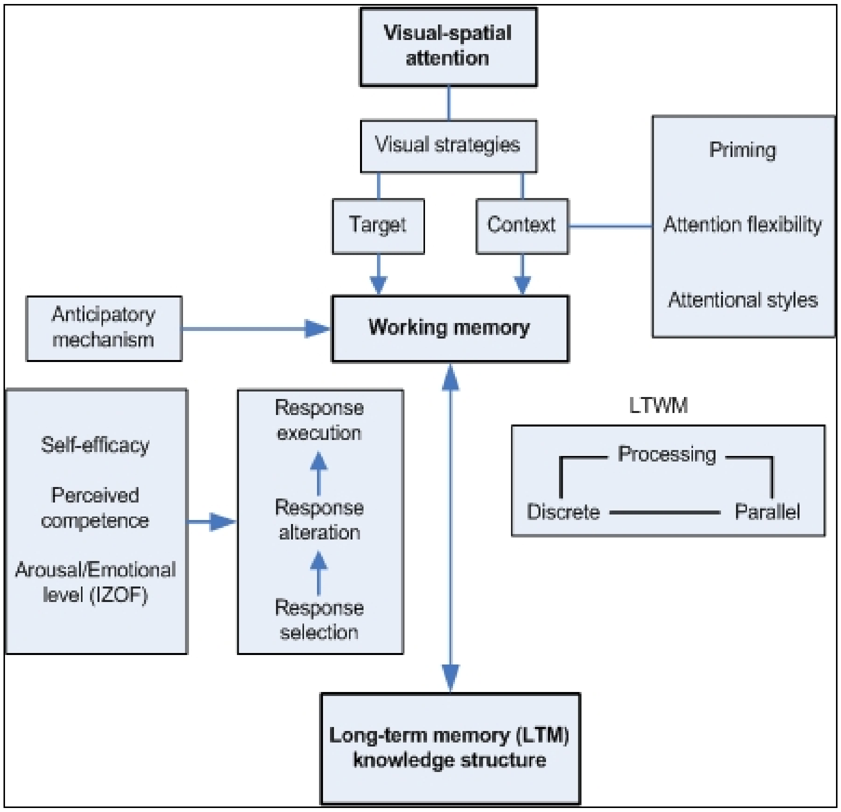

Figure 6. *A conceptual scheme of accessing decision-making in open-skill sport* (Tenenbaum, 2003).

The discussion will examine the process shown in Figure 6, with reference being made on how experts are thought to differ from novices in terms of these specific cognitive aspects (according to Tenenbaum, 2003).

2.4.4.1 Visual-spatial attention and search strategies

Visual search is regarded as a deliberate and applied process of locating the most relevant objects within a visual field for the purpose of further elaboration, through selection and discrimination to enable decision-making and implementation of motor actions. In sport, visual attention is required to detect, recognize, recall and select stimuli for higher-level processing when a decision is to be made and carried out in the form of a motor response. In open-skill type sports, the location of objects and subjects is used as a crucial cue for further processing, making decisions and carrying out the selected response to be executed (Tenenbaum, 2003). In rugby, the player has to be aware of the position of the ball and his own position on the field, the supporting players of his own team, as well as the defensive players of the opposing team when trying to assess the most appropriate attacking manoeuvre.

Once the field has been scanned in its entirety by the visual system, two strategies can be used to refine the visual search process, namely the target control strategy and the context control strategy (Neisser, 1967). The target control strategy consists of detecting targets within the display until a target is detected, which is compatible with the mental representations in long-term memory (Tenenbaum, 2003). In rugby the player carrying the ball searches the visual field until a supporting player runs himself into a position, practiced earlier, whereby the ball can be off-loaded to the supporting player enabling him to run into open space on the field and win some important field-position. The context control strategy consists of a visual search carried out under the control of memory representations, which are not necessarily sensitive to individual objects, but rather to a greater number of items in the display (Tenenbaum, 2003). When applying the context control strategy, the player relies more on recognizing the specific pattern of play produced by the positioning of supporting and defending players on the field and uses similar patterns stored in memory to decide on the most appropriate action to follow. The location of specific players is therefore no longer of importance, but rather their positioning on the field that allows the player carrying the ball to see where the open spaces are located.

It is posited, that with increased practice and experience, as the number of representations and their connections increase, expert players will shift from target control to context control so that they might reduce the information-processing complexity, increase the efficacy of the visual scan strategy and simplify the long-term working memory (Ericsson & Kintsch, 1995). Therefore, with increased exposure and experience, the expert comes to have more visual patterns in memory that can be accessed to simplify the representations of the positions of individual players on the field, into a coherent pattern of play. These levels of increased experience in searching the visual field contribute to greater levels of automaticity in identifying the most relevant areas of the field, allowing the expert player more time to think about what he is going to do, rather than wasting time on identifying individual players on the field that could contribute or interfere with the execution of the chosen action.

2.4.4.2 ENCODING, PROCESSING AND RETRIEVAL OF INFORMATION

Information from the visual system is fed forward for further processing until a motor response is chosen and executed. Two systems operate mutually at this given stage of information processing, namely the perceptual anticipatory system and a long-term working memory (LTWM) system. Pattern recognition from the environment results in advanced anticipatory recognition, as discussed in the section on the expert-novice paradigm, which allows the expert athlete to predict what is going to happen next. Anticipation and prediction is facilitated by repetitive exposure to competitive on-field experiences, which guides the sensory system to access knowledge structures held in memory (Tenenbaum, 2003). These knowledge structures account for a great deal of variability in the decision-making behaviours of athletes, with studies showing that expert athletes use shorter viewing times of the environment to make more accurate predictions about the future direction of the play, than novice or intermediate level athletes (Abernethy, 1987a).

These findings seem to suggest that expert athletes focus their visual attention on several cues simultaneously at early stages of the opponent's action initiation behaviours, rather than one cue at a time (Tenenbaum, Sar-El & Bar-Eli, 2000). This, in turn, suggests that expert athletes are able to process large amounts of visual information in parallel, rather than having to treat each incoming visual cue serially in order to make a prediction of future happenings in the play.

Superior knowledge about the future directions of play results in superior response selection and execution, as the response selection is heavily dependent on factors that are external to the athlete making the selection (Tenenbaum, 2003), for example the movements of opposing players. The actions and movements made by others require the athlete to alter the response selected initially and it is believed that the ability to alter one's own action develops with practice and experience, making it more evident in expert performers. As the central cues on which an initial decision was based become altered (an opposing player changes position) these cues attract more attention, resulting in the athlete focusing more attention on these cues as they become primed. Cues that attract more attention are therefore dealt with voluntarily, as their processing relies on the active attention of the athlete, while cues that are considered to be of less importance continue to be processed automatically. With enhanced levels of expertise, athletes are able to shift between the voluntary and automatic mechanisms of cue attention, which allows them to relate more selectively and efficiently to the dynamics and complexities of the open-skill sport environment (Nougier, Stein & Bonnel, 1991). The result of these complementary attention mechanisms working in combination is the ability of expert athletes to selectively attend to a small number of cues that are most pertinent, for example two defenders rushing up on the ball carrier, while the remainder of cues on the field that seem less pertinent, defenders that are far off on the field, are dealt with automatically. On the rugby field the alteration of action decisions can become very important, for example the kicker has decided to kick with his left foot, but two defenders rush up from his left, necessitating the kicker to quickly alter his behaviour and kick with his right foot.

With regards to the efficient recognizing of game-play patterns from long-term memory, it has been found that expert athletes seem to 'chunk' similar game-patterns together. These chunks contain large amounts of detail, which allows the expert to quickly recognize and assess the specific characteristics of the situation as a whole, rather than taking in all of the unnecessary details of the environment (Tenenbaum, 2003). The athlete can then access information about previous actions that have worked in similar situations to be carried out, but can also at the same time remain vigilant about changes to the visual field in the form of cues becoming more pertinent and important (Ericsson & Kintsch, 1995). In a sense the functioning of the athlete's long-term memory and working memory are combined, as representations are retrieved from long-term memory to represent the current on-field situation, with nuances in these representations being dealt with in working memory to adapt previous behaviours to the current situation.

2.4.4.3 AROUSAL AND SELF-EFFICACY

Perceptual anticipation and response selection do not function in a vacuum and despite the athlete's level of expertise other factors influence the degree to which one interprets perceptual information and chooses the appropriate executions, namely arousal, the individual zone of optimal functioning (IZOF) and self-efficacy.

It has often been found that when stress increases, athletes seem to alter and adapt their attention processes. Under low levels of stress, athletes process all incoming cues equally, whether they are relevant or not, which results in a lack of selectivity. Under moderate arousal levels, attention is paid only to the most relevant cues, thus simplifying the processing of information by making it more selective. Contrastingly, under extreme levels of stress and arousal, attention is narrowed greatly to exclude irrelevant and some relevant information (Tenenbaum, 2003). Therefore, when the athlete experiences difficulty in moderating his level of arousal, it is inevitable that important aspects of the environment will go unnoticed, resulting in wrong or bad decisions being made as a result of the incomplete processing of information. The individual athlete's zone of optimal functioning is closely related to this, as it refers to the regulation of emotional experience that most suited for optimal performance (Hanin, 2000). Different positions on a rugby team require different functions to be performed at different times during a match and it is important for specific players to be able to regulate their levels of emotional arousal in order to efficiently play out their roles. A front-row prop needs to increase his level of arousal each time a scrum takes place, which requires gross motor-behaviour, but he also needs to drastically decrease his level of arousal in situations when he is required to produce more finely skilled actions, like accurately passing the ball to a supporting player.

Lastly, the perceived level of confidence and self-efficacy of each player is an important indicator of the performance outcomes of physically demanding tasks (Tenenbaum, 2003). Each player on the field needs to have the self-belief that they will make the correct decisions and that they have the ability to correctly perform the selected action. This aspect of cognitive functioning was incorporated into the model, as it has been found that the level of decision-making and response execution strongly associated with expert players' level of self-belief to execute the selected response correctly and precisely (Tenenbaum, Levi-Kolker, Sade, Lieberman & Lidor, 1996). This model also incorporates aspects of declarative and procedural knowledge as a subcategory of the long-term knowledge structure, but as these concepts were discussed in detail previously, they will not be elaborated on further in this section.

Taken together, this model provides a coherent structure of information processing as it relates to the on-field decision-making of expert athletes by incorporating some of the most important findings made by use of the expert-novice paradigm.

2.5 THE DEVELOPMENT OF EXPERTISE IN SPORT

Much focus has historically been placed on the role of deliberate practice in the development of expertise in sport (Ericsson, 2003). The first study of expertise did not however involve sport, but rather the expert performance of world-class chess players and how these skilled players differed from novice chess players (de Groot, 1978). Enquiry into the subject continued into the 1970s and 1980s when Simon and Chase (1973) proposed that world-class chess players did not differ from novice players in terms of their basic mental capabilities and general capacities. Rather, Simon and Chase (1973) believed that the performance advantage of experts was attributed to their vast collection of knowledge and complex patterns, which they had accumulated during their many years of experience in playing chess (Ericsson, 2003). Expert performance, according to this approach, can therefore be regarded as the result of years of dedicated exposure to and practice in a given field, be it chess, music or sport. As stated earlier, Ericsson (1996) beliefs that ten years of deliberate practice is required for an individual to achieve a level of motor and cognitive expertise in sport, with deliberate practice being defined as 'the engagement of a person in a practice activity, most often designed by a teacher/coach, with the primary goal of improving some aspect of performance' (Ericsson, 2003).

The perception that deliberate practice is the only or most important manner, in which elite performance in sport is developed, is not universally shared. The main argument against deliberate practice is that it cannot be the only path towards expertise, as it often involves painstakingly long hours of repetitive behaviour that would very quickly diminish the commitment towards the sport of even the most talented athletes, with the result being that very few athletes are likely to participate in sport for very long. In order to address this shortcoming, Côté (1999) identified three phases within a developmental framework, specific to sport, to map the development of sport expertise from childhood to adolescence. These three stages or phases of developing sporting expertise are known as the sampling years (6-12 years of age), the specializing years (ages 13-15), and the investment years (16 years and older) (Côté, Baker & Abernethy, 2003). During the sampling phase, where the child is between 6-12 years old, parents are responsible for getting their child involved in sport, with children being given the chance to sample a range of different sports and to develop basic motor skills, such as running, jumping and throwing. The main purpose of sport during this phase is to experience the fun and excitement of sporting participation. During the specializing phase, which takes place between 13-15 years of age, the child focuses on one or two specific sporting activities and while the fun associated with participation, the development of sport-specific skills emerge as an important characteristic of the child's involvement in sport. Finally, the child moves into the investment years, at age 16 and older, during which the child becomes committed to achieving an elite or expert level of performance in a single type of sport. The strategic, competitive and skill development characteristics of sport emerge during this phase as being the most important elements of the investment years (Côté, 1999).

At this stage it is necessary to distinguish between two closely related terms, as they play different roles at different stages in the development of sporting expertise, namely *deliberate play* and *deliberate practice*. According to Ericsson, Krampe and Tesch-Römer (1993), the most effective learning takes place through involvement in a highly structured activity defined as deliberate practice, which they define as requiring effort, generating no immediate rewards, and as being motivated by the goal of improving performance rather than inherent enjoyment. Once again, it was suggested by these authors, that at least ten years of deliberate practice are needed to acquire expert sporting skills. Deliberate play, on the other hand, takes place during the early development stages and are generally designed to maximize inherent enjoyment. Deliberate play activities are governed by rules adapted from standardized sporting rules and are set in place and monitored by the children or an adult involved in the activity (Côté & Hay, 2002). The next section will be used to describe the developmental framework of expert athletes and the way in which the abovementioned concepts, among others, play a role in the acquisition of expert sporting skills.

2.5.1 SPORT INVOLVEMENT OF EXPERT ATHLETES THROUGHOUT THEIR DEVELOPMENT

Figure 7 shown below, illustrates the important training factors that change throughout the development phases of expert athletes, including the number of sporting activities they are involved in, the number of hours invested in deliberate practice and deliberate play as well as the social influences such as the roles of coaches, parent and peers at different stages in the developmental framework (Côté et al., 2003).

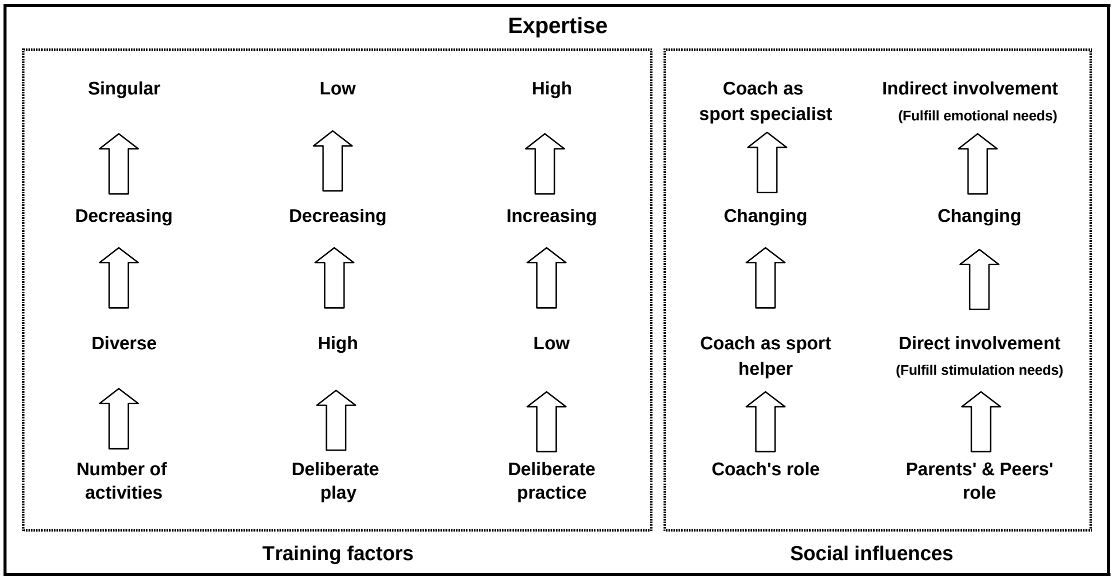

Figure 7*. Changes in social influences and training factors during the developmental years* (Côté, Baker & Abernethy, 2003).

2.5.1.1 NUMBER OF SPORTING ACTIVITIES

In a study conducted by Côté and Hay (2002) among expert and non-expert Australian athletes, it was found that the number of sporting activities these athletes were involved in differed as a function of their age. Between the ages of 5 to 12 years, both groups of athletes increased their participation in various sporting activities, but for expert athletes this was followed by a rapid decrease in other activities from age 13 onward, which marked their entry into the specialization years. A comparable reduction did not occur for non-expert athletes (Côté & Hay, 2002). Côté, Baker and Abernethy (2003) believe however, that the early specialization (before age 13) in a single sport is not a prerequisite for the development of expertise in that sport, as the involvement in a number of sports may actually enhance the range of motor skills the child can ultimately use in the principal sport of interest.

2.5.1.2 HOURS OF DELIBERATE PRACTICE

As mentioned earlier, the importance of deliberate practice, especially early in the lives of athletes, does not seem to be the best predictor of the development of expertise. Côté and Hay (2002) have emphasized the importance of deliberate play in the early years of elite athletes, as the enjoyment factor associated with it helps to keep young athletes involved in the sport for longer periods of time. The importance of deliberate practice does, however, increase as the young athlete progresses to the specializing phase and comes to be of greatest importance during the investment phase, when the athlete is required to learn specialized skills that can only be mastered through long hours of repetitive practice (Côté et al., 2003), as shown in Figure 7 above.

2.5.1.3 Hours of deliberate play

According to Côté et al. (2003) it is the playful environment found during the early years of a child's involvement in sport that may explain the early learning and high levels of motivation of expert athletes, as it appears to lead to subsequent learning and involvement in deliberate practice. As mentioned above, it was found that early specialization and highly structured training involving a coach or parent can reduce intrinsically motivated behaviour and can lead to more young athletes dropping out of the sport (Gould, Udry, Tuffey & Loehr, 1996). Because children are motivated to participate in deliberate play by their own interest in the activity, this type of early involvement may help children to gain a better grasp of their ability and might subsequently affect their decision to stay involved in their sport of choice (Brustad, Babkes & Smith, 2001).

2.5.1.4 Role of coaches in developing expertise in young athletes

As the cognitive, physical and emotional needs of children change at various stages of their sport participation, it is important that the role of coaches change accordingly. Expert coaches have been shown to provide both physical and social resources to overcome the monotony and motivational constraints associated with deliberate practice (Côté et al., 2003). In a study by Abernethy *et al.* (2002) it was shown that athletes' descriptions of their coaches' intervention in the first stage of their career focused on engagement in motor activities to encourage the development of fundamental movement skills that eventually come to be the foundation of learning more complex skills later in life. It was further found that athletes started to develop a closer relationship with their coaches at around age 13, or at the onset of the specializing phase. At the same time, coaching tended to become more technical and serious regarding the athletes involvement in practice and training. It is believed that such a transition in the coach's role from being 'child-centred' in the sampling years, to becoming more of a 'sport specialist' in the investment years, may strengthen the athlete's commitment to increasing the quantity and intensity of their training and to pursuing their sport to a higher level (Côté et al., 2003).

2.5.1.5 Role of parents and peers in developing expert athletes

In a study by Côté (1999), it was found that the role of parents in the development of expert athletes, most likely, changes from a leadership role in the sampling years to a supporter role in the investment years. During the sampling years, the parent assumes a leadership role by encouraging their children to be involved in various types of sporting activities, as part of the child's overall development. The specializing years see the parent becoming more of a committed supporter of their child's decision to limit the number of sporting activities in which they are involved. During the investment years, the involvement in the child's sporting activities becomes more indirect as it consists mainly of becoming a spectator at games or providing opportunities at home and elsewhere for their child to be involved in deliberate practice activities (Côté et al., 2003).

It makes sense that the first three factors mentioned in this framework of the development of expertise in sport developed by Côté, Baker and Abernethy (2003), namely that of number of sporting activities, hours of deliberate practice and play can have a direct influence on becoming an expert in one's chosen sporting code. The social influences i. e. the roles played by parent, peers and friends do not, on the surface, seem to have such a direct influence on the development of expertise, but these factors were included in the discussion to provide an holistic view on the influences that have an effect on the development of expert athletes. Said differently, the development of expert athletes does not take place in a sporting "vacuum", but these athletes still form part of a larger social network that has in impact on their development, as mentioned by Côté, Baker and Abernethy (2003).

The role of peers in the development of expert athletes follows a similar pattern as for parents. During the sampling years, the interaction with peers is driven by the young athlete's need for stimulation through deliberate play, resulting in the involvement of peers being very direct. As athletes progress to the investment phase, at around age 16, peer relationships become more intense and fulfil motivational and emotional needs that may facilitate involvement in deliberate practice activities (Côté et al., 2003).

2.6 SUMMARY

Having discussed the basic assumptions of the expert-novice paradigm, the naturalistic paradigm and the information processing approach, it would seem that the latter provides the best basis for studying the quality and process of decision-making in expert rugby players as it allows the researcher to get an in-depth look at what happens in between the identification of a stimulus and the execution of a chosen behavioural action. Although this is by no means an exhaustive discussion of the three approaches or the development of sporting expertise, it should provide a primary understanding of these perspectives and their approach to studying decision-making.

3. RESEARCH METHODOLOGY

3.1 RESEARCH PROBLEM

The goal of this study is to develop a self-report measurement scale aimed at enabling expert rugby players the opportunity to assess their personal on-field playing performance as it relates to the making of quality decisions in real-life, on-field situations occurring under severe time pressure. For the purpose of this study, the research problem can be posed as follows: Does a difference exist in the quality of on-field decision-making, measured in terms of visual search strategies, anticipation and response selection, of junior and senior expert rugby players as measured by a self-report measurement scale? If a difference does exist in the quality of on-field decision-making of junior and senior expert rugby players, as it is likely to be the case as a result of various factors, one should be able to accurately measure these differences by means of the abovementioned scale.

As previously stated, the most central aspects of quality on-line decision-making that need to be assessed in open-skills sport experts are: (1) the visual strategies employed to search for relevant stimuli information in the dynamic environment, (2) the anticipatory mechanisms used in conjunction with working memory to predict what is going to happen next, and (3) the long-term memory structure that holds the declarative and procedural knowledge that has been acquired through years of on-field experience, which enables the player to make the decision he/she regards as the best in the given circumstances (Tenenbaum, 2003). The essence of the response selection or decision-making stage therefore lies in deciding which part of the environment to look at (visual search strategies), making predictions about what is likely to happen next (anticipation) and deciding on how to react to these anticipated changes (response selection). Items were included in the questionnaire to represent each of these decision-making phases, with respondents being required to give an indication, by means of a self-reported score, of their personally perceived ability to carry out this each of these phases of decision-making as discussed later in this section. Therefore, one has focus on the isolated role and effect, as well as the interplay, of these aspects in order to study and assess decision-making in a dynamic, open-skill sport like rugby.

3.2 RESEARCH HYPOTHESES

The hypothesis on which this research is based includes the independent variable of level of expertise with two levels of either being a junior or senior level expert rugby player and the dependent variable of decision-making quality, based on visual search strategies, anticipation or working memory and selection of response.

The research hypotheses can be stated as follows:

> H_0: No difference exists in the self-reported quality of on-field decision-making, measured in terms of visual search strategies, anticipation guided by working memory and response selection, of senior level expert rugby players, compared to that of junior level expert rugby players.
>
> H_1: The self-reported quality of on-field decision-making, measured in terms of visual search strategies, anticipation guided by working memory and response selection, of senior level expert rugby players is higher than that of junior level expert rugby players.

3.3 RESEARCH DESIGN

This study will take on the form of a one-group post-test-only quasi-experimental design, which involves making observations on only those persons that have undergone a treatment only after they have received it (Cook & Campbell, 1979). Although no direct treatment condition will be involved in conducting the study, one can consider the participant's rugby playing experience as the 'treatment-condition' they bring into the study, with their participation in the study being the post-test. The aim of the study is not to measure the impact or influence of any treatments, but is rather more exploratory in nature, as it is aimed at studying a subject that is relatively new and this type of design assists in the development of methods that can be useful for future, in-depth enquiry (Rubin & Babbie, 2001). This will be achieved with the use of a self-administered survey taking on the form of a factorial design, which contributes to the uncovering of the complex sets of interrelationships present in the study of expert decision-making. This type of analytic survey design allows the researcher to approximate laboratory conditions, as it facilitates the selection of participants who already have the characteristics required by the study (Oppenheim, 2004). The factorial design provides the opportunity of studying several experimental variables in combination, not only providing more information but also with greater confidence in the prediction of results (Tacq, 1997). Further, by providing an empirical estimate of the underlying structure of the variables considered, factor analysis becomes an objective basis for creating summated scales or factors with a minimum loss of information (Hair, Anderson, Tatham & Black, 1998). The use of factor analysis was therefore considered to be appropriate, as it allowed for the grouping of the various items included in the questionnaire into those underlying factors or dimensions associated with the actions taken on the field with regards to decision-making in the expert rugby context.

According to Whitley (2003) self-report measures can focus on a number of different human functions. In this study, the most important self-reports tapped by the items in the questionnaire included cognitive self-reports which dealt with what players think about when they have to make decisions on the field, as well as behavioural self-reports, which focused on what players do when they are in certain situations on the field (also known as *hypothetical* reports). The main reason for using a self-report measure in this study is the fact that it allows the researcher to gain access to information that is not directly observable, for example what players look at and think about when they have to cope with and make decisions in certain situations on the field.

There are however some limitations to the use of self-report measures that can threaten the internal validity of the study, of which inaccurate self-appraisal caused by evaluation apprehension can hold the biggest threat to the accuracy of results and conclusions drawn (Whitley, 2003). Although the threat of player overconfidence in their ability to carry out the actions assessed by the test items cannot be denied or totally controlled for, participants were instructed to try and be as truthful as possible about their own skill levels when completing the questionnaire. The fact that questionnaires were completed anonymously could also have contributed to more accurate scores being given, although it is impossible from the researcher's point of view to gauge the difference between actual and reported ability levels.

Events taking place outside of the testing environment just prior to the completion of the questionnaires could also have had an influence on the self-evaluation of the players, a threat commonly referred to as *history* (Cook & Campbell, 1979) . Given that the sample was made up out of players that represent different teams at the BBRU, it might very well have been the case that players' self-evaluations were influenced by the results of the matches they played in on the weekend prior to data gathering taking place. Members from winning teams might have felt more confident in their own abilities than members from losing teams, resulting in inaccurate ability scores being reported. Also, at the time of data gathering, junior and senior teams competing in different competitions were playing according to different sets of playing rules, known as *Experimental Law Variations* (ELV's), which could also have led to uncertainty and under confidence in personal ability in certain players caused by having to learn, adapt to and play according to these new sets of rules. These rule changes were however employed in the entire country and it was not limited to players from the BBRU or those taking part in the study.

Concerning the external validity of the study, uncertainty exists as to the extent with which the results can be generalized across expert rugby players from different rugby unions across the country. The BBRU is currently one of the strongest rugby unions in South Africa, with many of the players in the sample having won provincial and junior international competitions. For this reason it would be irresponsible to regard the results of the study as being representative of all expert rugby players in South Africa, as some of the players in the sample are the best in their position and age group in the country.

3.4 PARTICIPANTS

As the aim of the study is to design an inventory that can be used to measure the level of decision-making of expert rugby players, it was thought best to involve such players when trying to establish the criteria it is measured against. Whitley (2003) refers to the selection of participants according to the goals of the research, as purposive sampling, with the researcher viewing each participant as a typical case of the population they belong to. Purposive sampling is regarded as a non-random, non-probability sampling technique, as not all of the expert rugby players in the country had an equal opportunity of being included in the study sample. As mentioned above, the players included in the final sample were regarded as being 'typical cases', therefore being considered as representing all of the expert rugby players in the country. The sample included 74 professional under-19, under-21, Vodacom Cup and Super 14 players from the BBRU. The distinction between either being a junior or senior player was based on the fact of having played Vodacom Cup, international age-group world cup or Super 14 rugby, which is considered to be on a level above domestic age-group rugby. Therefore, those players from the sample that have played at least one Vodacom Cup, international age-group world cup or Super 14 game, prior to the study taking place, were considered to be senior players. These players can be regarded as being expert players, as most of them have been the national champions over three of the last four years in their age-group competitions and all of them play rugby as their profession.

3.5 MEASUREMENT INSTRUMENT

A questionnaire consisting of 40 items related to the key aspects of decision-making in open-skill sport environments and four items related to basic demographic information on the players' rugby playing history, was used to assess the self-reported levels of decision-making of the participant expert rugby players. The item-pool was made up of items focusing on each of the central aspects of expert decision-making, as identified in the literature review, which included twelve items on visual strategies, fourteen items on working memory and anticipation and thirteen items on response selection. One item was also included on which the players were asked to give an indication of their overall skill-level as an expert rugby player. The same rating scale was used as for all of the other decision-making items. Each of the decision-making items was assigned a score ranging from 1 = poor to 5 = excellent based on the self-rated on-field performance of the players. The demographic information required from the players included their age, preferred playing position, years of playing experience and highest playing level achieved.

The questionnaire was loosely based on an instrument used by Elferink-Gemser *et al*. (2004) to measure the decision-making quality among 415 competitive youth field hockey and soccer players. Factor analysis was used to formulate four scales, which together form what the authors call *The Tactical Inventory for Sports.* Internal consistency and test-retest measures for reliability were found to be within acceptable limits, with the construct validity also supported by the fact that expert players obtained better scores on the measurement instrument than non-expert players (Elferink-Gemser et al., 2004). The appropriate results from the study by Elferink-Gemser *et al.* (2004) will be discussed in full when comparing it with the results of the current study in the following chapter. The questionnaire was adapted to include items that can be applied to an expert rugby context and as mentioned above, it was completed by 74 expert rugby players that differ in terms of playing experience, preferred playing position and age. The items were formulated to include all of the aspects of expert on-field decision-making considered to be of importance in consensus with two expert rugby coaches, also associated with the BBRU. The aim of including the demographic information in the analysis was to determine whether these factors have an influence on the quality of on-field decision-making.

Given the limited sample size involved in the study, it was decided not to make use of a test-retest reliability assessment of the items used for constructing the instrument. Taking into account the size of the sample and given the fact that results taken at different times in the year may vary as a result of extraneous variables, such as players taking part in different levels of competition during the season, it was thought that it might not be beneficial to extend the assessment of players over a long period of time. In dealing with these challenges the reliability of the measurement instrument was assessed by randomly assigning each of the participants into one of two groups after having completed the item list and then comparing the results obtained from each of the groups, by use of statistical techniques discussed under the section on data analysis. The reliability of the inventory was further assessed by conducting subsequent split-half reliability evaluations in order to identify whether the inventory did in fact have internal consistency (Kerlinger, 1979).

Issues regarding the construct validity of the instrument were dealt with by strictly adhering to the theory (Whitley, 2003) on the three dimensions of high levels of decision-making in sporting contexts i.e. visual search strategies, anticipation and response selection, as outlined by Tenenbaum (2003) when items were chosen and constructed for inclusion in the initial item pool. With these dimensions firmly in mind, a total of 22 items applicable to the rugby context were selected from the questionnaire used in the study by Elferink-Gemser *et al*. (2004), with the remaining 17 items being constructed with the help of the expert rugby coaches. Items were only included in the initial item pool if they were considered to be consistent with the three dimensions proposed by Tenenbaum (2003). Elferink-Gemser *et al.* (2004) found construct validity to be further supported by the fact that expert youth hockey and soccer players performed better on *The Tactical Inventory for Sports* than non-elite players. Having already referred to the importance of the long-term memory structure, which holds the declarative and procedural knowledge acquired through years of on-field experience which enables the player to make the decision he/she regards as the best in the given circumstances (Tenenbaum, 2003), the assumption can be made that senior level players would have more on-field experience than junior level players, as a result of having played rugby for a longer period of time and at a more competitive and challenging level. In the study by Elferink-Gemser *et al.* (2004) the level of playing experience was found to be related with the scores obtained on the questionnaire, with senior level players scoring themselves higher than junior level players, giving an indication that construct validity is supported by the results. These results will also be discussed in full in the next chapter.

As mentioned above, content and face validity was also addressed by involving some of the expert coaches of the BBRU in a discussion on the practical aspects of quality on-field decision-making they consider to be of importance to be included in the questionnaire. These coaches were also involved in compiling the questionnaire, in an effort to ensure that the items included covered all of the major dimensions of decision-making in terms of practical on-field situations, as identified in the theory on procedural and declarative decision-making. As mentioned in a previous section, declarative knowledge includes knowledge of the rules and goals of the game (Williams & Davids, 1995) whereas procedural knowledge involves the selection of an appropriate action within the context of the game (McPherson, 1994). An example of the measurement of declarative knowledge can be seen in the item 'I apply my knowledge of the rules accurately to matches' (Variable 17). The belief was however shared by the researcher and the professional coaches, that considering the expertise level of the players involved, the majority of items should focus on procedural knowledge i.e. the selection of appropriate responses on the field, rather than their knowledge of the rules, which is very good as a result of in-depth rules coaching and their constant involvement in the game. Lastly, criterion validity was assessed by comparing scores obtained in this study to the scores obtained by Elferink-Gemser *et al.* (2004) on items used in both questionnaires. These results will be discussed in the following chapter, together with all of the other results pertaining to the study. This could be achieved as both studies are aimed at assessing the on-field decision-making of expert players, with the only difference being the sports in which they participate.

3.6 DATA COLLECTION PROCEDURES

The questionnaire was administered to all of the 74 players under controlled conditions at the facilities of the BBRU. Each individual player anonymously completed a questionnaire after giving informed consent to participating in the study by completing an informed consent form. The informed consent form is included under Appendix J. As mentioned earlier, the questionnaire was made up of items adapted from the study conducted by Elferink-Gemser *et al.* (2004), as well as items constructed by the researcher in conjunction with the expert coaches. The items originally used by Elferink-Gemser *et al.* (2004) were modified to be applicable to a rugby context, as the original items were designed to be used in soccer and field-hockey. Examples of these items include statements such as "If my team receives the ball I know exactly what to do" and "During matches I look not only at the ball but also over the field". The complete questionnaire is included under Appendix A. Each statement was subsequently assigned a score on a rating scale, according to the players self-reported skill level in carrying out each action, as described above. Before the start of the questionnaire completion session, the participants were instructed to answer each of the items in terms of their personal on-field performance and to try and answer as accurately and honestly as possible. The participants were also informed of the anonymity of their responses and as a measure to guarantee that the responses stayed anonymous, the consent forms were collected separately from the completed questionnaires, on which no personal information was included.

3.7 DATA ANALYSIS

As the study involves the development of a measurement scale, factor analysis, followed by a varimax rotation (Kerlinger, 1979) was used to group items in the appropriate categories of dependent variables. The Cronbach alpha statistic was utilised to assess the consistency and reliability of responses on similar items between sample groups as well as the internal consistency of the inventory (Creswell, 2003). Descriptive statistics were utilized to compute the means and standard deviations of scores assigned to each item in the questionnaire, allowing comparisons to be made between the scores reported by respondents from both playing levels in order to assess the construct validity of the instrument. The general-skill item (Question 45 in the questionnaire) was further used as a Y-variable in a regression analysis, in order to identify the phases of decision-making that seem to be directly related to the general skill-level of the participating players. The results of the study will be discussed in detail in the following chapter.

4. DATA ANALYSIS

4.1 INTRODUCTION

The following chapter will be used to present the results of the study, acquired through the methods discussed in the methodology chapter. A total number of 74 expert rugby players (mean age = 20.04 years, *SD* = 2.4 years, range = 18 – 33 years) completed the questionnaire, which consisted of four demographic items and 39 questions related to the study of decision-making quality. Of the 74 participants, 47 were classified as junior-level expert players, with the remaining 27 players being classified as senior-level players. On average, junior-level players had 10.4 years (*SD* = 3.5 years) of rugby playing experience, while players who had previously played senior-level rugby, had been playing rugby for an average of 12.5 years (*SD* = 4.7 years. As mentioned earlier, players who had played at least Vodacom Cup rugby were regarded as senior-level players.

4.2 RELIABILITY OF MEASUREMENT INSTRUMENT

The reliability of the measurement instrument was assessed by randomly assigning each of the participants in the sample to one of two experimental groups in order to simulate an independent sample group's assessment of reliability, which could not be done by testing the players on two different occasions, as mentioned earlier. SPSS version 14, a statistical software package, was used to randomly categorize each of the participants into two groups of equal size. The goal of this was firstly, to determine the extent to which the two groups could be considered as being equivalent in terms of their demographic information and composition, and secondly to verify the reliability of the measurement scale had it been completed on two different occasions. The groups were compared through the use of the Mann-Whitney U test, which is a non-parametric or distribution-free test. This test was considered the most appropriate, as none of the factors included in the comparison (with the possible exception of the highest playing level achieved) were normally distributed, as shown in Appendix B.

Table 1 *Comparison of demographic information of two random groups*

	Group A	Group B	Sig.[a]
Number of participants per group (n=74)	33	41	
Mean age of participants in years	20.0	20.1	0.562
Years of playing experience in years	11.4	10.8	0.754
Playing position			0.516
Highest playing level achieved			0.616

[a].Mann-Whitney U Asymptotic signifcance (2-tailed)

The results shown in Table 1 indicate that participants from the two randomly selected groups did not differ significantly in terms of their demographic information. The apparent equivalence of the two sample groups, as a result of the random assignment of participants, allowed for an estimation of the reliability of the measurement instrument, as if it were completed by two equivalent sample groups taken from the same rugby player population.

Summary scores recorded on different combinations of items included in the measurement scale were used for comparing the two sample groups. These summary scores were calculated by, for example, summating the scores achieved on visual search strategy items and dividing this score by the number of visual search strategy items in the questionnaire, of which there were 13. Summary scores were similarly calculated for anticipation and response selection, with each player therefore receiving a summary score for each of the three decision-making phases as outlined by Tenenbaum (2003). A total decision-making score was also calculated for each player. This was achieved by calculating an average score for all of the 39 decision-making items included in the questionnaire. Similar scores were calculated for the different areas of play, namely attacking, defensive and general play by identifying the items that depict attacking, defensive or general play and computing the average score achieved by each player for each area of play. The grouping of items according to decision-making phase and area of play are shown in Table 6 and 6b. The calculating of summary scores for decision-making phase and area of play therefore resulted in six sub-scale scores, together with a total decision-making score, as shown below in Table 8.

The comparison was conducted through the use of an Independent Samples T-test. This method of analysis was chosen because the distributions of the summary scores approached normality, with the possible exception of Visual Search Strategies, as shown in Appendix C. The results again showed that no significant difference existed between the use of the measurement scale for Group A and Group B, as shown in Table 2. Therefore, it can be concluded that the measurement scale is reliable for this specific rugby player population, although it does not show reliability across different time periods of its use. Further research is however needed to gauge the reliability of the scale when completed by different player populations at different times during the rugby season.

Table 2 *Comparison of summary scores of two random groups*

n=74	Group	*df*	Mean	SD	*t*	Sig.[a]
Visual Search	A	72	3.43	0.39	0.24	0.994
	B		3.43	0.44		
Anticipation	A	72	3.33	0.48	0.19	0.499
	B		3.26	0.46		
Response Selection	A	72	3.53	0.51	-1.10	0.566
	B		3.59	0.38		
Offensive Play	A	72	3.40	0.46	-0.27	0.755
	B		3.37	0.45		
General Play	A	72	3.48	0.51	-0.12	0.870
	B		3.50	0.47		
Defensive Play	A	72	3.44	0.47	-0.38	0.856
	B		3.46	0.39		
Decision-making	A	72	3.42	0.39	-0.24	0.811
	B		3.44	0.43		

[a]. Independent Samples T-test. Sig. 2-tailed (Equal variances assumed)

All p-values for Levene's test of equality of variance $p > 0.05$.

Given that a variety of items were included in the measurement scale in order to assess the quality of the participant's on-field decision-making in terms of their visual search strategies, anticipation and response selection, it was necessary to assess the internal consistency of the measurement scale. This was done firstly, by randomly dividing the 40 non-demographic items completed by the participants into two groups and computing the correlation between the participants' total scores on the two parts (Whitley, 2002); referred to as split-half reliability. The split-half reliability analysis yielded a correlation between the two forms of $r = 0.768$, being above the prescribed minimum internal consistency coefficient of $r = 0.70$ (Whitley, 2002). The categorization of items is shown in Appendix D.

Table 3 *Reliability coefficients for summary scores and split-half reliability analysis*

Reliability Analysis of Decision-making Summary Scores for all Participants (n = 74)

	Cronbach's Alpha
Reliability of decision-making Summary Scales (n = 3 Items)	0.914
Reliability of Visual Search Items (n = 14 Items)	0.794
Reliability of Anticipation Items (n = 12 Items)	0.815
Reliability of Response Selection Items (n = 14 Items)	0.832

Reliability Analysis of Decision-making Summary Scores for Randomly Selected Groups (n = 74)

		Cronbach's Alpha
Reliability of decision-making Summary Scales (n = 3 Items)	Group A	0.901
	Group B	0.93
Reliability of Visual Search Items (n = 14 Items)	Group A	0.767
	Group B	0.822
Reliability of Anticipation Items (n = 12 Items)	Group A	0.758
	Group B	0.855
Reliability of Response Selection Items (n = 14 Items)	Group A	0.839
	Group B	0.824

Reliability Analysis of Area of Play Summary Scores for all Participants (n = 74)

	Cronbach's Alpha
Reliability of area of play Summary Scales (n = 3 Items)	0.877
Reliability of Attacking Play Items (n = 15 Items)	0.846
Reliability of Defensive Play Items (n = 10 Items)	0.818
Reliability of General Play (n = 14 Items)	0.816

Reliability Analysis of Area of Play Summary Scores for Randomly Selected Groups (n = 74)

		Cronbach's Alpha
Reliability of decision-making Summary Scales (n = 3 Items)	Group A	0.85
	Group B	0.899
Reliability of Attacking Play Items (n = 15 Items)	Group A	0.821
	Group B	0.868
Reliability of Defensive Play Items (n = 12 Items)	Group A	0.804
	Group B	0.839
Reliability of General Play Items (n = 15 Items)	Group A	0.809
	Group B	0.831

Split-half Reliability Analysis for all Participants (n = 74)

	r
Correlation between forms	0.768

Split-half Reliability Analysis for Randomly Selected Groups (n = 74)

	r
Correlation between forms	0.728

The results of all the reliability analyses are shown in Table 3. Reliability among decision-making summary scores refers to the correlation among the totals achieved by all players on visual search strategies, anticipation and response selection. The reliability of area of play summary scales was calculated in the same fashion, with the correlation between totals for attacking, defensive and general play being calculated. Although the same item scores were used to calculate the summary scales for both decision-making and area of play, the high reliability scores should not have been influenced by this fact, given that no single item total score was included in more than one summary score. The combinations of items included under each decision-making and area of play summary score are shown in Tables 6a and 6b. The reliability analysis shown in Table 3 suggests that an acceptable level of internal consistency can be found among the items included in the instrument, indicating that they are measuring the same traits. Further, the measurement instrument should remain stable across time when applied to the same or similar participant populations, as the internal consistency of a measure is reasonably well related to its stability across time (Schuerger, Zarella & Hotz, 1989).

4.2 Demographic characteristics of the sample

The demographic characteristics of the participant sample are shown in Table 4. The participants were asked to indicate their preferred playing position, age, years of playing experience and the highest playing level they had achieved to date. For the sake of simplicity, responses were grouped into categories for age and years of playing experience. Responses to preferred playing position were also grouped together, with props, hookers and locks making up the tight five, flank and eight men combining to form the loose trio, with players preferring to play scrumhalf, flyhalf, wing, centre and fullback forming the backline.

Table 4 *Basic demographic information of participants*

Preferred playing position (n = 70)

	Frequency	Percentage
Prop	10	14.3%
Hooker	6	8.6%
Lock	7	10.0%
Flank	17	24.3%
Eightman	4	5.7%
Scrumhalf	5	7.1%
Flyhalf	7	10.0%
Wing	3	4.3%
Centre	8	11.4%
Fullback	3	4.3%

Grouped preferred playing position (n = 70)

	Frequency	Percentage
Tight Five	23	31.0%
Loose Trio	21	28.4%
Backline	26	35.1%

Grouped age (n = 70)

	Frequency	Percentage
18 - 20 years	48	68.6%
21 - 23 years	18	25.7%
24 - 26 years	2	2.9%
27 - 29 years	1	1.4%
Older than 30	1	1.4%

Years of playing experience (n = 65)

	Frequency	Percentage
1 - 3 years	2	3.1%
4 -6 years	9	13.9%
7 - 10 years	9	13.9%
11 - 15 years	40	61.5%
16 + years	5	7.7%

Highest playing level achieved (n = 74)

	Frequency	Percentage
First team at school	4	5.4%
Provincial school	12	16.2%
Club rugby	11	14.9%
Provincial age group	20	27.0%
Vodacom Cup	14	18.9%
Currie Cup	7	9.5%
Higher	6	8.1%

Level of play (n = 74)

	Frequency	Percentage
Junior level	47	63.5%
Senior level	27	36.5%

As shown in Table 4 all of the playing positions were represented in the sample and when looking at the grouped playing position data it becomes clear that all three positional groups (tight five, loose trio and backline) made up a relatively equal part of the sample. Participants were not as equally distributed according to their age groups, with 94% of the players being under the age of 23. This age distribution was expected beforehand, as none of the full-time Super 14 Blue Bulls players (who are by comparison older) were part of the sample, given that they were taking part in this international competition and therefore could not be included in the sample. This factor also contributed to the fact that the sample included more junior players (n=47) than senior players (n=27). Although the majority of players involved in the study can be considered as being very young, they are very experienced in terms of playing rugby, with almost 70% of participants indicating that they have been playing rugby for at least 11 years. In terms of the highest playing level achieved the distribution of participants, as shown in Figure 1, can be considered as being relatively normal, with the majority of players having played provincial school-, club-, provincial age group-, or Vodacom Cup rugby.

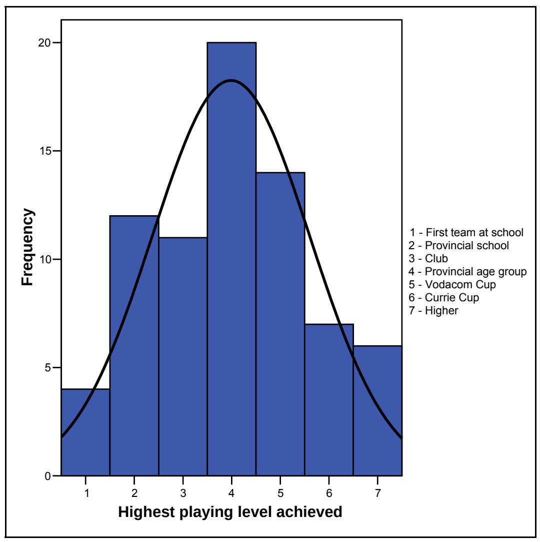

Figure 8*. Distribution of highest playing level achieved*

When participants were grouped according to their years of playing experience, it became apparent that players with more than ten years of playing experience scored themselves significantly higher in terms of their decision-making quality than players with less than ten years of playing experience. The results are shown in Table 5. Contrastingly, decision-making quality was not found to differ as a function of age.

Table 5 *Comparison of summary scores grouped according to playing experience*

		Years of playing experience				
		Less than 10 years	**More than 10 years**	**Total**	***df***	**Sig[a]**
Visual search	Mean	3.26	3.49	3.44	63	0.04*
	Median	3.15	3.54	3.46		
	Std Dev	0.41	0.41	0.41		
Anticipation	Mean	3.12	3.36	3.30	63	0.049*
	Median	3.17	3.42	3.29		
	Std Dev	0.48	0.45	0.47		
Response selection	Mean	3.43	3.62	3.57	63	0.115
	Median	3.36	3.57	3.57		
	Std Dev	0.42	0.44	0.45		
Decision-making	Mean	3.27	3.49	3.43	63	0.042*
	Median	3.23	3.54	3.41		
	Std Dev	0.39	0.40	0.41		

* Significant at $p < 0.05$

[a].Independent Samples T-test. Sig. 2-tailed (Equal variances assumed)

All p-values for Levene's test of equality of variance $p > 0.05$.

As an overview, the average participant in the sample was, at the time of data collection, 19.5 years old, had 12 years of playing experience, with provincial age group rugby being the highest playing level achieved.

4.3 Calculation and presentation of summary scores

As mentioned earlier, summary scores were calculated for each of the theoretical components of on-field decision-making, namely visual search strategies, anticipation and response selection, as outlined by Tenenbaum (2003). Table 6 shows the categorization of items according to their location in the decision-making process. Items were further categorized according to the area of play the actions described in the items belong to, with items depicting attacking-, defensive- or general playing behaviour being grouped together. The grouping of items into each of the area of play categories (attack, defence or general) is shown in Table 7. For example, items grouped under visual search strategies, include items 1, 2, 6, 9, 11, 17, 21, 24, 25, 28, 32, 38 and 39. This strategy was used in categorizing all items into phases of decision-making and areas of play, as shown in Table 6 and Table 7.

Table 6 *Grouping of items according to decision-making process*

Visual Search Items

1. When in possession of the ball, my ability to look for open space is
2. During matches my ability to look not only at the ball, but also over the field is
6. When on defense, I can quickly identify where the attacking players are
9. Without looking at only one player, I know where my opponent's are moving to
11. During matches my ability to follow the ball is
17. When in possession of the ball, my ability to look for the defenders is
21. My overview of the game, whether in defense or possession is
24. When in possession of the ball, I can quickly identify where the defenders are
25. When in defense, my ability to focus on opponents in my defensive channel is
28. When in defense, my ability to focus on the ball is
32. When in possession of the ball, my ability to look for supporting players is
38. When I receive the ball, I do not have to look where my teammates are, I already know
39. When in defense, my ability to focus on opponents outside of my defensive channel is

Anticipation Items

3. I can quickly identify the weak points of my opponents
4. When in I am in defense, I know quickly what my opponent is going to do
5. If our team loses ball possession during a match, I quickly switch to my task as defender
8. If a teammate receives the ball, I know exactly what he is going to do
14. I am accurate about predicting what is going to happen next in a match
15. When on attack, I know how to get into open space during a match
16. If an opponent receives the ball, I know exactly what he is going to do
22. My ability to react quickly from defending to being in possession of the ball is
26. If I receive the ball from a teammate, I know in advance where to move the ball
29. When in possessions of the ball, I can quickly predict what the defense is going to do
33. My positioning during a match is generally
36. When in I am on attack, I know quickly what my opponent is going to do

Response Selection Items

7. If I posses the ball, I know exactly to whom I have to pass
10. If our team get turnover ball, my support play is generally
12. I apply my knowledge of the rules of the game accurately to matches
13. I am good at making the right decisions at the right moments
18. I am generally able to make quick on-field decisions
19. Compared to other players, my playing within the laws of the game is
20. If my team receives the ball I know exactly what to do
23. When in defense of a second or later phase, I know exactly which position to take
27. When in defense of a first phase, I know exactly which position to take
30. I have the ability to take actions on the field that lead to positive results for my team
31. While executing an action in a match, I know exactly what I will have to do next
34. I know exactly when to pass the ball to a teammate or when not to
35. If our team loses ball possession, I know exactly what to do
37. I quickly react to rectify mistakes of my teammates

Table 7 *Grouping of items according to area of play*

Attacking Play Items

1. When in possession of the ball, my ability to look for open space is
7. If I posses the ball, I know exactly to whom I have to pass
8. If a teammate receives the ball, I know exactly what he is going to do
10. If our team get turnover ball, my support play is generally
15. When on attack, I know how to get into open space during a match
17. When in possession of the ball, my ability to look for the defenders is
20. If my team receives the ball I know exactly what to do
22. My ability to react quickly from defending to being in possession of the ball is
24. When in possession of the ball, I can quickly identify where the defenders are
26. If I receive the ball from a teammate, I know in advance where to move the ball
29. When in possessions of the ball, I can quickly predict what the defense is going to do
32. When in possession of the ball, my ability to look for supporting players is
34. I know exactly when to pass the ball to a teammate or when not to
36. When in I am on attack, I know quickly what my opponent is going to do
38. When I receive the ball, I do not have to look where my teammates are, I already know

Defensive Play Items

4. When in I am in defense, I know quickly what my opponent is going to do
5. If our team loses ball possession during a match, I quickly switch to my task as defender
6. When on defense, I can quickly identify where the attacking players are
16. If an opponent receives the ball, I know exactly what he is going to do
23. When in defense of a second or later phase, I know exactly which position to take
25. When in defense, my ability to focus on opponents in my defensive channel is
27. When in defense of a first phase, I know exactly which position to take
28. When in defense, my ability to focus on the ball is
35. If our team loses ball possession, I know exactly what to do
39. When in defense, my ability to focus on opponents outside of my defensive channel is

General Play Items

2. During matches my ability to look not only at the ball, but also over the field is
3. I can quickly identify the weak points of my opponents
9. Without looking at only one player, I know where my opponent's are moving to
11. During matches my ability to follow the ball is
12. I apply my knowledge of the rules of the game accurately to matches
13. I am good at making the right decisions at the right moments
14. I am accurate about predicting what is going to happen next in a match
18. I am generally able to make quick on-field decisions
19. Compared to other players, my playing within the laws of the game is
21. My overview of the game, whether in defense or possession is
30. I have the ability to take actions on the field that lead to positive results for my team
31. While executing an action in a match, I know exactly what I will have to do next
33. My positioning during a match is generally
37. I quickly react to rectify mistakes of my teammates

Summary scores were calculated for each participant by adding the scores reported on each item and dividing the summated score by the number of items in each category. The mean, median and standard deviation scores for junior and senior level players are shown in Table 8. A total decision-making score was also calculated for the junior- and senior-level players. This score was calculated by adding the scores obtained from each of the decision-making subscales (visual search strategies, anticipation and response selection) and dividing this summated score by the number of summary scales, of which there were three. Although senior players scored higher than junior level players on all of the summary scores, as well as the total decision-making score, the only scores on which the differences could be considered to be statistically significant were that of response selection and general play, with the total decision-making score approaching significance with p = 0.095.

Table 8 *Statistics for summary scores for decision-making process and area of play*

Summary Scores						
		Junior level	Senior level	Total	*df*	Sig[a]
Visual Search	Mean	3.39	3.50	3.43	72	0.280
	Median	3.31	3.54	3.46		
	Std Dev	0.41	0.42	0.42		
	Minimum	2.69	2.69	2.69		
	Maximum	4.23	4.15	4.23		
Anticipation	Mean	3.23	3.39	3.29	72	0.168
	Median	3.17	3.42	3.25		
	Std Dev	0.45	0.49	0.47		
	Minimum	2.42	2.33	2.33		
	Maximum	4.33	4.33	4.33		
Response Selection	Mean	3.48	3.71	3.57	72	0.031*
	Median	3.50	3.71	3.57		
	Std Dev	0.42	0.44	0.44		
	Minimum	2.57	3.00	2.57		
	Maximum	4.50	4.50	4.50		
Attacking Play	Mean	3.33	3.48	3.39	72	0.157
	Median	3.20	3.53	3.27		
	Std Dev	0.46	0.43	0.45		
	Minimum	2.47	2.53	2.47		
	Maximum	4.33	4.20	4.33		
Defensive Play	Mean	3.46	3.55	3.49	72	0.432
	Median	3.50	3.60	3.50		
	Std Dev	0.47	0.51	0.49		
	Minimum	2.60	2.60	2.60		
	Maximum	4.50	4.40	4.50		
General Play	Mean	3.37	3.60	3.45	72	0.025*
	Median	3.36	3.57	3.43		
	Std Dev	0.38	0.47	0.43		
	Minimum	2.57	2.79	2.57		
	Maximum	4.07	4.57	4.57		
Decision-making	Mean	3.37	3.53	3.43	72	0.095
	Median	3.33	3.59	3.35		
	Std Dev	0.39	0.41	0.40		
	Minimum	2.66	2.91	2.66		
	Maximum	4.25	4.30	4.30		

* Significant at p < 0.05
[a].Independent Samples T-test. Sig. 2-tailed (Equal variances assumed)
All p-values for Levene's test of equality of variance p > 0.05.

In terms of the individual items in the measurement scale, senior players achieved higher scores on all of the items, except those items shown in Table 9. These items include the following:

- 5. If your team loses ball possession during a match, I quickly switch to my task as defender.
- 10. If our team get turnover possession, my support play is generally.
- 23. When in defense of a second or later phase, I know exactly which position to take.

- 24. When in possession of the ball, I can quickly identify where the defenders are.
- 28. When in defense, my ability to focus on the ball is.
- 29. When in possession of the ball, I can quickly predict what the defense is going to do.

Considering the decision-making process, it is interesting to note that two of these items belonged to the visual search grouping, two to anticipation and two to the response selection class, giving the impression that these higher scores were of a random nature. In terms of the area of play, three of these items depicted attacking play, with the remaining three depicting defensive play, with senior players outscoring junior players on all general play items. It must, however, be mentioned that none of these differences could be considered statistically significant, as shown by the probability values in Table 9.

Table 9 *Items on which junior level players scored higher than senior level players*

Item		Junior level	Senior level	Total	*df*	t-value	Sig[a]
5. If our team loses ball possession during a match, I quickly switch to my task as defender	Mean	3.87	3.85	3.86	72	0.096	0.924
10. If our team get turnover ball, my support play is generally	Mean	3.51	3.44	3.49	72	0.321	0.749
23. When in defense of a second or later phase, I know exactly which position to take	Mean	3.62	3.44	3.55	72	0.917	0.362
24. When in possession of the ball, I can quickly identify where the defenders are	Mean	3.51	3.33	3.45	72	1.073	0.287
28. When in defense, my ability to focus on the ball is	Mean	3.79	3.70	3.76	72	0.467	0.642
29. When in possessions of the ball, I can quickly predict what the defense is going to do	Mean	3.30	3.26	3.28	72	0.183	0.855

[a]. Independent Samples T-test. Sig. 2-tailed (Equal variances assumed)
All p-values for Levene's test of equality of variance p > 0.05.

When these items are excluded from calculating the summary scores shown in Table 6, the difference in the quality of on-field decision-making of junior and senior level players becomes statistically significant, as shown in Table 10. The exclusion of these items does not significantly influence the composition of the questionnaire, as two items are excluded from each decision-making phase, with items 24 and 28 being excluded from visual search strategies, items 5 and 29 from the section on anticipation and items ten and 23 from the section on response selection. A new total decision-making score can therefore be calculated in the same fashion as mentioned above, with the abovementioned items being excluded from the analysis. The new comparisons between junior and senior level players are shown in Table 10.

Table 10 *Adjusted summary scores for decision-making phases and total*

Adjusted summary scores for decision-making

		Junior level	Senior level	Total	*df*	Sig[a]
Visual search	Mean	2.83	2.96	2.88	72	0.141
	Median	2.77	3.07	2.85		
	Std Dev	0.36	0.36	0.36		
Anticipation	Mean	3.16	3.36	3.23	72	0.092
	Median	3.10	3.30	3.15		
	Std Dev	0.46	0.50	0.48		
Response selection	Mean	3.47	3.76	3.58	72	.008*
	Median	3.42	3.67	3.50		
	Std Dev	0.42	0.46	0.45		
Decision-making	Mean	3.15	3.36	3.23	72	.031*
	Median	3.11	3.41	3.15		
	Std Dev	0.37	0.40	0.39		

* Significant at $p < 0.05$

[a].Independent Samples T-test. Sig. 2-tailed (Equal variances assumed)

All p-values for Levene's test of equality of variance $p > 0.05$.

The exclusion of these items allows for the rejection of the null-hypothesis in favour of the alternative hypothesis, given that senior players scored significantly higher than junior level players in terms of their decision-making quality in general. It would, however, be necessary to have the item list completed in its entirety by a larger sample of players before permanently excluding the six items mentioned above from the questionnaire in order to verify these results.

The complete list of items included in the measurement scale are shown in Table 11, 10b and 10c, with only five items indicating a statistically significant difference between the scores achieved by junior and senior level players, with five other items approaching significance at $p < 0.1$. The distribution of summary scores is shown in Appendix C.

Table 11 *Visual search items included in the measurement scale*

Visual Search Items		Junior level	Senior level	Total	*df*	t	Sig*
1. When in possession of the ball, my ability to look for open space is	Mean	3.17	3.37	3.24	43.448	-1.215	0.231
	Median	3	3	3			
	Std Dev	0.56	0.74	0.64			
2. During matches my ability to look not only at the ball, but also over the field is	Mean	3.4	3.63	3.49	59.532	-1.298	0.199
	Median	3	4	4			
	Std Dev	0.77	0.69	0.74			
6. When on defense, I can quickly identify where the attacking players are	Mean	3.53	3.67	3.58	70.232	-0.835	0.407
	Median	4	4	4			
	Std Dev	0.83	0.55	0.74			
9. Without looking at only one player, I know where my opponent's are moving to	Mean	3.02	3.22	3.09	52.89	-0.993	0.325
	Median	3	3	3			
	Std Dev	0.82	0.85	0.83			
11. During matches my ability to follow the ball is	Mean	3.47	3.85	3.61	63.547	-2.034	0.046*
	Median	3	4	4			
	Std Dev	0.88	0.72	0.84			
17. When in possession of the ball, my ability to look for the defenders is	Mean	3.51	3.52	3.51	64.365	-0.46	0.963
	Median	4	4	4			
	Std Dev	0.8	0.64	0.74			
21. My overview of the game, whether in defense or possession is	Mean	3.49	3.56	3.51	54.653	-3.95	0.695
	Median	3	3	3			
	Std Dev	0.69	0.70	0.69			
24. When in possession of the ball, I can quickly identify where the defenders are	Mean	3.51	3.33	3.45	49.409	1.04	0.303
	Median	3	3	3			
	Std Dev	0.66	0.73	0.69			
25. When in defense, my ability to focus on opponents in my defensive channel is	Mean	3.45	3.59	3.50	54.902	-0.712	0.48
	Median	3	4	3			
	Std Dev	0.85	0.84	0.85			
28. When in defense, my ability to focus on the ball is	Mean	3.79	3.70	3.76	46.868	0.445	0.658
	Median	4	4	4			
	Std Dev	0.69	0.82	0.74			
32. When in possession of the ball, my ability to look for supporting players is	Mean	3.40	3.44	3.42	43.405	-0.167	0.868
	Median	3	3	3			
	Std Dev	0.83	1.09	0.92			
38. When I receive the ball, I do not have to look where my teammates are, I already know	Mean	3.11	3.30	3.18	44.988	-0.886	0.38
	Median	3	3	3			
	Std Dev	0.76	0.95	0.83			
39. When in defense, my ability to focus on opponents outside of my defensive channel is	Mean	3.21	3.30	3.24	44.895	-0.428	0.671
	Median	3	3	3			
	Std Dev	0.69	0.87	0.76			

Table 12 *Anticipation items included in the measurement scale*

Anticipation Items		Junior level	Senior level	Total	*df*	t	Sig*
3. I can quickly identify the weak points of my opponents	Mean	3.26	3.44	3.32	52.487	-0.851	0.399
	Median	3	3	3			
	Std Dev	0.9	0.93	0.91			
4. When in I am in defense, I know quickly what my opponent is going to do	Mean	3.11	3.19	3.14	43.305	-0.355	0.725
	Median	3	3	3			
	Std Dev	0.76	1	0.85			
5. If our team loses ball possession during a match, I quickly switch to my task as defender	Mean	3.87	3.85	3.86	63.653	0.101	0.92
	Median	4	4	4			
	Std Dev	0.95	0.77	0.88			
8. If a teammate receives the ball, I know exactly what he is going to do	Mean	2.89	3.11	2.97	54.261	-1.011	0.317
	Median	3	3	3			
	Std Dev	0.89	0.89	0.89			
14. I am accurate about predicting what is going to happen next in a match	Mean	2.96	3.15	3.03	48.873	-1.007	0.319
	Median	3	3	3			
	Std Dev	0.72	0.82	0.76			
15. When on attack, I know how to get into open space during a match	Mean	3.11	3.52	3.26	56.601	-1.791	0.079
	Median	3	4	3			
	Std Dev	0.98	0.94	0.98			
16. If an opponent receives the ball, I know exactly what he is going to do	Mean	2.81	2.85	2.82	45.007	-0.25	0.803
	Median	3	3	3			
	Std Dev	0.61	0.77	0.67			
22. My ability to react quickly from defending to being in possession of the ball is	Mean	3.45	3.74	3.55	67.267	-1.796	0.077
	Median	4	4	4			
	Std Dev	0.80	0.59	0.74			
26. If I receive the ball from a teammate, I know in advance where to move the ball	Mean	3.47	3.67	3.54	56.904	-1.026	0.309
	Median	3	4	3			
	Std Dev	0.83	0.78	0.81			
29. When in possessions of the ball, I can quickly predict what the defense is going to do	Mean	3.30	3.26	3.28	45.998	0.173	0.863
	Median	3	3	3			
	Std Dev	0.81	0.98	0.87			
33. My positioning during a match is generally	Mean	3.47	3.67	3.54	51.4	-1.147	0.257
	Median	3	4	4			
	Std Dev	0.69	0.73	0.71			
36. When in I am on attack, I know quickly what my opponent is going to do	Mean	3.11	3.22	3.15	50.098	-0.71	0.481
	Median	3	3	3			
	Std Dev	0.63	0.70	0.66			

Table 13 *Response selection items included in the measurement scale*

Response Selection Items		Junior level	Senior level	Total	*df*	t	Sig*
7. If I posses the ball, I know exactly to whom I have to pass	Mean	3.45	3.93	3.62	48.156	-2.173	0.035*
	Median	3	4	4			
	Std Dev	0.83	0.96	0.9			
10. If our team get turnover ball, my support play is generally	Mean	3.51	3.44	3.49	54.808	0.322	0.749
	Median	3	3	3			
	Std Dev	0.86	0.85	0.85			
12. I apply my knowledge of the rules of the game accurately to matches	Mean	3.47	3.93	3.64	51.423	-2.341	0.023*
	Median	4	4	4			
	Std Dev	0.78	0.83	0.82			
13. I am good at making the right decisions at the right moments	Mean	3.11	3.41	3.22	38.982	-1.759	0.086
	Median	3	3	3			
	Std Dev	0.52	0.8	0.65			
18. I am generally able to make quick on-field decisions	Mean	3.36	3.52	3.42	45.082	-0.869	0.389
	Median	3	3	3			
	Std Dev	0.64	0.8	0.7			
19. Compared to other players, my playing within the laws of the game is	Mean	3.79	4.07	3.89	49.316	-1.414	0.164
	Median	4	4	4			
	Std Dev	0.78	0.87	0.82			
20. If my team receives the ball I know exactly what to do	Mean	3.53	3.89	3.66	55.593	-2.096	0.041*
	Median	4	4	4			
	Std Dev	0.72	0.7	0.73			
23. When in defense of a second or later phase, I know exactly which position to take	Mean	3.62	3.44	3.55	44.955	0.862	0.394
	Median	4	3	4			
	Std Dev	0.71	0.89	0.78			
27. When in defense of a first phase, I know exactly which position to take	Mean	3.70	4.11	3.85	56.059	-2.085	0.042*
	Median	4	4	4			
	Std Dev	0.83	0.80	0.84			
30. I have the ability to take actions on the field that lead to positive results for my team	Mean	3.62	3.78	3.68	50.135	-0.737	0.465
	Median	4	4	4			
	Std Dev	0.85	0.93	0.88			
31. While executing an action in a match, I know exactly what I will have to do next	Mean	3.47	3.59	3.51	56.038	-0.68	0.499
	Median	3	3	3			
	Std Dev	0.78	0.75	0.76			
34. I know exactly when to pass the ball to a teammate or when not to	Mean	3.43	3.52	3.46	57.127	-0.585	0.561
	Median	3	4	3			
	Std Dev	0.68	0.64	0.67			
35. If our team loses ball possession, I know exactly what to do	Mean	3.47	3.78	3.58	42.297	-1.577	0.122
	Median	3	4	4			
	Std Dev	0.65	0.89	0.76			
37. I quickly react to rectify mistakes of my teammates	Mean	3.28	3.56	3.38	52.309	-1.317	0.194
	Median	3	3	3			
	Std Dev	0.85	0.89	0.87			
40. In general, please give an indication of your overall skill-level as a rugby player	Mean	3.60	3.93	3.72	50.285	-1.808	0.077
	Median	4	4	4			
	Std Dev	0.71	0.78	0.75			

* Significant at α=0.05

[a]. Independent Samples T-test. Sig. 2-tailed (Equal variances not assumed)

When comparing the summary scores of players in terms of their grouped preferred playing positions, it is interesting to note that tight five and loose-trio players significantly outscored backline players on defensive play items, while tight five players also outscored backline players on response selection items. The complete set of multiple comparison scores are shown in Appendix E. Furthermore, when comparing the summary scores of players with more decision-making responsibility in the team, namely the scrumhalf, flyhalf, inside centre and eight man, to players in other positions, high responsibility players scored themselves significantly lower on response selection and overall decision-making ability. The results for this comparison are shown in Table 14.

Table 14 *Comparison of summary scores between low and high responsibility players*

		Low responsibility players	High responsibility players	Total	*df*	Sig[a]
Visual search	Mean	3.49	3.33	3.44	64.82	0.072
	Median	3.54	3.35	3.46		
	Std Dev	0.46	0.29	0.41		
Anticipation	Mean	3.35	3.20	3.30	66.97	0.146
	Median	3.33	3.17	3.29		
	Std Dev	0.53	0.31	0.47		
Response selection	Mean	3.65	3.40	3.57	60.44	0.013*
	Median	3.71	3.39	3.57		
	Std Dev	0.47	0.34	0.45		
Decision-making	Mean	3.50	3.31	3.43	65.68	0.036*
	Median	3.57	3.31	3.41		
	Std Dev	0.45	0.28	0.41		

* Significant at $p < 0.05$

[a].Independent Samples T-test. Sig. 2-tailed (Equal variances not assumed)

All p-values for Levene's test of equality of variance $p < 0.05$.

4.4 REGRESSION ANALYSIS

As mentioned earlier, an item was included in the measurement scale aimed at measuring the participant's general ability level on all facets of play that read as follows: "In general, please give an indication of your overall skill-level as a rugby player." The reason for including this item was to conduct a regression analysis, which allows for the prediction of one variable (overall skill-level) from knowledge of one or more other variables (Howell, 1989). This was achieved in this study by comparing the summary scores related to the decision-making process, namely visual search strategies, anticipation and response selection, to the scores achieved on the overall-skill item and then conducting a regression analysis, by means of the stepwise method, in order to determine which of the summary scores was the best predictor of self-reported overall rugby skill.

Table 15 *Regression analysis for overall skill-level*

Regression Model Summary [b, c]

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.984[a]	0.969	0.968	0.676

a: Predictors: Response Selection

b: Dependent Variable: In general, please give an indication of your overall skill-level as a rugby player

c: Linear Regression through the Origin

As shown in Table 15 the Response Selection summary score was the strongest predictor of overall rugby skill, with the summary scores of Visual Search Strategies and Anticipation being completely excluded as having a significant influence on overall skill-level, as these summary scores only achieved significance levels of p = 0.71 and p = 0.717 respectively. The complete regression analysis results are shown in Appendix F. It therefore seems that response selection has the biggest influence on a player's ability to make decisions of a high quality on the field. It must however be kept in mind that these results were obtained through the use of a self-rating scale, which can lead to overconfidence in the scoring of personal ability and skill, and it is therefore likely that this could have lead to the high correlation between the items. This is illustrated in the high mean scores and above average minimum scores achieved on the summary scores as shown earlier in Table 8.

4.5 FACTOR ANALYSIS

Principal component analysis of the 39 item test, followed by varimax rotation, yielded a structure consisting of 12 factors which accounted for 71% of the response variation. With eigenvalues set above 1.5 the number of factors in the structure was reduced to six, which accounted for 52% of response selection. Factor 1 alone accounted for 27% of the variation in responses, with the remaining 5 factors accounting for between 6% and 4% of response variations, as shown in Appendix G. Appendix H shows the allocation of items to their respective factors. It must be noted that the allocation of items to the 6 different factors, as shown in Appendix H, did not allow for the meaningful construction of new decision-making components, as was the case in the study conducted by Elferink-Gemser et al. (2004), as most of the factors included items depicting actions included in a variety of the decision-making process components set out by Tenenbaum (2003). Factor 1, for instance, included items on visual search strategies ('When in defence, my ability to focus on the ball' and 'When in defence, my ability to focus on opponents outside of my defensive channel'), as well as response selection ('When in defence of a first phase, I know exactly which position to take', 'I know exactly when to pass the ball to a team mate or when not to' and 'If our team loses ball possession, I know exactly what to do'). Viewed in terms of the area of play, the items belonging to factor 1 include actions related to attacking play, as well as defensive play. The relatively small sample size included in the study might have contributed to the abovementioned result, as it is generally recommended that the sample size should be 2.5

times larger than the number of items included in the measurement instrument (Howell, 1989). It would however be premature to reject the applicability of the decision-making process model proposed by Tenenbaum (2003) in a rugby context before testing the measurement instrument among larger sample groups.

The purpose of including a factor analysis in the study was to determine the extent to which the decision-making process described by Tenenbaum (2003) would be supported by the results of this study. As the abovementioned process was not developed for use in a rugby-playing context, it was deemed necessary to test its applicability. Given the fact that the items included in the measurement instrument were based on the theory of a three-component decision-making process, as outlined by Tenenbaum (2003) and that these items taken together account for 52% of response variations in terms of on-field decision-making, it would not be meaningful to force the construction of new decision-making components that would contain items depicting dissimilar types of on-field actions. As the underlying factors identified through the factor analysis included items depicting such divergent on-field actions, it is not possible to group these items together in a meaningful fashion, as all of the underlying factors would have to be labelled as depicting general areas of play.

It would however seem premature to abandon the use of the three step decision-making process proposed by Tenenbaum (2003) in a rugby-playing context, as further study with larger sample sizes is necessary to determine the model's usefulness. This topic will be dealt with in more detail in the next chapter where the implications of the results of the study are discussed.

4.6 CONSTRUCT VALIDITY

As mentioned above, senior-level players outscored junior-level players on all of the decision-making process summary scores as hypothesized, as shown in Table 8. Although a statistically significant difference in mean scores between the two groups was only found for response selection and on the decision-making total when the six items are excluded on which junior players outscored senior players, as shown in Table 10, it can nevertheless be assumed that the construct validity of the measurement instrument was supported by these results. Given the relatively small sample size employed in this study, it would be necessary to apply the measurement instrument to larger sample sizes in order to confirm these results.

5. DISCUSSION OF RESULTS

5.1 INTRODUCTION

This chapter will be used to discuss the results of the study as it relates to the quality of self reported on-field decision-making of junior and senior level expert rugby players. Firstly, the discussion focuses on the apparent influence of demographic factors on decision-making quality, before turning to the final discussion, composition and recommendations of the measurement instrument developed from the results of the study.

5.2 DEMOGRAPHIC FACTORS AND DECISION-MAKING QUALITY

The original questionnaire developed for use in this study included four items aimed at gathering demographic information on the participating 74 expert rugby players, which included preferred playing position, player age at the time of the study, the amount of rugby playing experience measured in terms of the total number of years playing rugby, as well as the highest playing level achieved in their careers.

5.2.1 PLAYING POSITION

With players grouped according to playing positions into either tight-five, loose forwards or the backline, results showed that tight-five players had the most confidence in their decision-making ability, compared to backline and loose forward players. This result is interesting, given the fact that tight five players are generally less required to make decisions on the field that would influence the direction and result of the game, as compared to backline players and loose forwards. In general, the largest decision-making responsibilities would lie with the team's scrumhalf and flyhalf, together with the eight man and inside centre, which excludes the tight five. It was found that players with less decision-making responsibility achieved significantly higher scores on response selection and overall decision-making quality, than players whose decisions generally have a larger influence on the game. These findings could have come about as a result of the way in which the questionnaire was completed. As self-report measures are susceptible to the individual's self-confidence, and since self-confidence is associated with expert performance in various sports (Woodman & Hardy, 2003), this might have had an influence on the results. The high level of confidence, or even overconfidence, showed by low responsibility decision-making players might stem from the fact that the decisions made by these players seldom have a very large influence on the direction and consequent outcome of any game. When, for example, a tight five player makes a less than ideal decision the consequences of the decision might not be all that visible to onlookers, compared to when a flyhalf or scrumhalf makes a bad decision. It is therefore possible for low responsibility decision-makers to make bad decisions and 'get away with it', as it would not necessarily have a large influence on the outcome of a game. Therefore, when a player is not reprimanded for bad decision-making it could lead to an over-inflated perception of one's ability to make quality decisions, as personally perceived ability is largely influenced by being confronted with all aspects of on-field performance (Elferink-Gemser et al., 2004).

5.2.2 AGE AND YEARS OF PLAYING EXPERIENCE

When participants were grouped according to their age no significant difference was found in the self-reported decision-making quality between younger and older players. This result might stem from the fact that players did not differ very much in age, because 94% of participants were between 18 and 23 years of age.

Years of playing experience did however seem to have a significant effect on the players' ability to make high quality on-field decisions. Players with more than ten years of playing experience scored themselves higher in terms of perceived on-field decision-making quality, as measured by the entire measurement instrument, than did players with less than ten years of rugby playing experience. In a way these results seem to support the findings of Ericsson (1996) mentioned earlier, which state that ten years of experience and deliberate practice is required for an individual to achieve a level of motor and cognitive expertise in sport. Given the limitations associated with self-report methods, most notably the threat of results being over inflated as a consequence of overconfidence in personal ability, these results do seem to support the notion that the prolonged involvement of an athlete in a specific sporting code, for example rugby, does have an influence on the athlete's mental capabilities associated with expert performance in that sport. As mentioned earlier, expert athletes rely heavily on previous on-field experiences, stored in long-term memory, to inform and guide the decisions made in every new playing situation they find themselves in (Ericsson & Kintsch, 1995). Players with more than ten years of playing experience are able to make better on-field decisions because they have more experiences stored in their long-term memory to utilize when new decision-making situations present themselves.

5.2.3 HIGHEST PLAYING LEVEL ACHIEVED

Of the 74 expert rugby players involved in this study, 47 of these players were categorized as junior level expert players, with the remaining 27 being regarded as senior level expert rugby players. As mentioned earlier, players who have played at least one Vodacom Cup or age group world cup game were considered to be senior level players. Junior level players included in the sample had, at the time of the study, played rugby for either, the first team at high school, a provincial high school team, a club, or a provincial age group team, while senior level players had played Vodacom Cup, Currie Cup, Super 14 or international rugby.

The aim of the study was to develop a measurement instrument that can be used by expert rugby players to assess the quality of their own decisions made on the field of play. It was hypothesized, according to the theoretical points of departure discussed earlier, that the measurement instrument should yield higher scores in terms of decision-making quality for more experienced or senior level players, compared to less experienced, junior level players. In comparing the scores achieved on visual search strategies, anticipation, response selection and decision-making in general, it was found that senior level players scored themselves higher than junior players on all of the measured constructs, with a significant difference found for response selection. These results are similar to findings by, among other, Williams, Davids and Williams (1999) who found that expert athlete's posses advanced domain specific cognitive and perceptual abilities and functional knowledge acquired over many years of sporting experience. Given that, on average, junior level players had only two years less playing experience than senior level players (although the median score for total years of playing experience for both groups was 12 years), total years of playing experience does influence the development of domain specific cognitive abilities, such as decision-making. Given the small difference in years of playing experience, as shown by the median scores which to a certain extent excludes outlying scores provided by a minority of the older players in the sample, it should not be the predominant factor influencing decision-making quality. The difference between the intensity, competition and speed at which junior and senior level rugby is played should have a much more prominent effect on one's ability to develop the ability to make quality decisions, as senior level rugby requires players to make high quality decisions under much increased time pressure as compared to junior level rugby. Although years of playing experience cannot be totally ignored as having an influence on decision-making ability, the experience of having to compete at higher levels of competition seems to be a better predictor of developing high quality decision-making ability in a rugby specific context.

5.2.4 AREA OF PLAY

As shown in Table 7, items were also grouped according to the area of play they represent, namely attacking play, defensive play and general play. The results showed no significant differences in the scores obtained on the attacking and defensive play sub-scales between junior and senior players. Senior players did however achieve significantly higher scores on the general play sub-scale, which included, among others, items depicting actions related to positioning, playing within the rules of the game and identifying the weak points of one's opponents. Compared to one's ability on attacking and defensive play actions, which is often 'drilled' into the player through highly structured coaching techniques, general playing ability is less associated with coaching and more with a player's level of playing experience. Information stored in long-term memory on similar situations encountered previously (Summers, 2004) on the rugby field comes to be of grave importance for the expert rugby player in this instance. Having previously experienced a number of situations characterized by extreme time pressure constraints, as is often found in senior level rugby allows the athlete to use the information stored in long-term memory to react accordingly. This supports the notion that level of playing experience has an influence on a player's all-round playing ability, as the actions depicted by the general play items cannot be easily taught, but should develop as a result of learning from one's mistakes on the field, as well as playing on a higher competitive level where one's mistakes are more often exploited by opposing players.

5.2.5 DECISION-MAKING AND OVERALL ABILITY

A single item was also included in the measurement instrument that required players to give an indication of their overall rugby playing ability. The purpose of including this item was to determine the degree, through use of a regression analysis, to which each of the decision-making processes in the model by Tenenbaum (2003) could be used to predict overall rugby playing ability. The results of the regression analysis showed response selection to be the best predictor of overall rugby playing ability, with visual search strategies and anticipation being excluded as strong predictors of this overall skill in junior and senior level players.

As it has been found that expert athlete's posses superior visual cue recognition and anticipation abilities (Williams, Davids & Williams, 1999), the results of this study seem to indicate that superior response selection is what distinguishes players with a higher overall ability from players with a lower overall ability. Given the fact that all of the players included in the study can be considered expert rugby players, the results seem to indicate that high overall ability expert players do not differ significantly from lower overall ability expert players in terms of their visual search strategies and anticipation skills. In a study by Abernethy, Farrow and Berry (2003), it was found that expert athletes are characterized by superior pattern recognition and anticipation skills. Rather the results seem to indicate that, presented with the same visual information and anticipating similar consequences, high ability players are better at selecting the 'correct' responses required by the situation, which can lead to more favorable results for the team. Given the results, it seems that high overall ability expert players posses a more refined procedural knowledge, which involves the selection of an appropriate action within the context of the game (McPherson, 1994). It therefore makes sense to conclude that the essence of being a highly skilled rugby player lies in the ability to select the most appropriate response when confronted with a specific situation on the field and not just in focusing on the most appropriate visual information presented by the situation, or correctly anticipating the likelihood of subsequent events.

5.3 THE DECISION-MAKING MEASUREMENT INSTRUMENT

The objectives of this study were aimed at the development of a self-report measurement instrument that can be used by expert rugby players to determine the quality of their own on-field decision-making ability. The method by which this was achieved was by constructing an initial measurement instrument made up of 39 initial items focusing on decision-making quality. The initial pool of items were assembled according to the three phases of decision-making, namely visual search strategies, anticipation and response selection, as described by Tenenbaum (2003), together with the input from two expert rugby coaches associated with the BBRU. As mentioned earlier, the initial visual search strategies sub-scale consisted of 13 items, while the anticipation and response selection sub-scales consisted of 12 and 14 items respectively. The initial item pool is shown in Appendix A.

It was hypothesized that, as a result of various factors discussed earlier, senior level expert rugby players should achieve significantly higher scores in terms of their decision-making quality than junior level expert rugby players. The measurement instrument should therefore be able to distinguish between senior and junior level players, by yielding significantly higher scores on the sub-scales, as well as the total decision-making score, for senior level players as compared to junior level players.

The instrument in its original form consisting of 39 items, yielded scores on the visual search strategies and anticipation sub-scales, as well as on total decision-making, that did not differ significantly between junior and senior level players. The only sub-scale that showed a significant difference was that of response selection, with senior players achieving significantly higher scores than junior players. When comparing the mean scores achieved by junior and senior players on each of the items, it was shown that junior level players achieved higher scores on a total of six items included in the original item pool, as shown in Table 9. Although junior players did not achieve significantly higher scores than senior players on any of these items, the inclusion of these items did have an influence on the mean differences between the two groups on each of the sub-scales and on the total decision-making score.

With these six items excluded from the initial item pool, with two items belonging to each of the three decision-making sub-scales, the difference between the total decision-making quality of junior and senior level players did increase to a level of statistical significance. The exclusion of these items therefore contributes to the ability of the measurement instrument to assess the difference in decision-making quality of senior and junior level expert rugby players. It must however be mentioned that the scores achieved on visual search strategies and anticipation did not change to a level of significance between the two groups compared. It would however be necessary to verify these results by having the instrument completed by a larger sample of expert rugby players before excluding the six items shown in Table 9 for good. The final measurement instrument shown in Appendix I did however yield results that support the hypothesis that senior level players make better on-field decisions than junior level players.

5.3.1 RESULTS OF THE FACTOR ANALYSIS

As mentioned earlier, the purpose of including a factor analysis in the study was to determine the extent to which the decision-making process described by Tenenbaum (2003) would be supported by the results of this study. Given the fact that this theory of decision-making was not specifically developed for use in a rugby-playing context, it was deemed necessary to test it applicability. The results of the analysis conducted in this study did not however support the grouping of items included in the measurement instrument according to the decision-making phases as set out by Tenenbaum (2003). The relatively small sample size included in the study might have contributed to the abovementioned result, as it is generally recommended that the sample size should be 2.5 times larger than the number of items included in the measurement instrument (Howell, 1989). It would however be premature to reject the applicability of the decision-making process model proposed by Tenenbaum (2003) in a rugby context before testing the measurement instrument among larger sample groups. It is likely that subsequent factorial analyses would increasingly support the model of decision-making as consisting of three successive phases, namely visual search strategies, anticipation and response selection. The fact that senior level players significantly outscored junior level players on overall decision-making quality, as predicted by the model and as measured by the adjusted measurement instrument, support the use of the three-phase decision-making model in a rugby context.

In summary, the internal consistency of the measurement instrument was acceptable, with the construct validity being supported by the fact that senior level players achieved higher scores in terms of their decision-making quality than junior level players. The decision-making quality measurement instrument can therefore be used to assess the total decision-making quality of expert rugby players, measured in terms of their self-reported ability.

6. RECOMMENDATIONS AND SHORTCOMINGS

The results of this study show that the on-field decision-making of expert rugby players can be measured through the use of a self-report measurement instrument. Use of the measurement instrument can yield valuable results for trainers and coaches of expert rugby players, as well as the players themselves, as it provides a valid and reliable method for determining strong and weak points in decision-making ability. Given that the instrument was developed according to a three-step decision-making model, this allows for a precise specification of where players are going wrong in their decision-making processes. By determining player's strong and weak points in visual search strategies, anticipation or response selection, effective coaching techniques can focus on developing the skills lacked by individual expert players in an effort to improve overall decision-making ability. This would contribute to player's being aware of the aspects of their play that needs to be developed. Where decision-making training techniques are already in place, the measurement instrument can be used to assess the effectiveness of these training techniques or programs. By using the same measurement instrument over an extended period of time, each player can track the development of his/her specific individual decision-making abilities.

The results of the study can not however be generalized to all expert rugby players in South Africa, as the measurement instrument was developed through the participation of a relatively small group of respondents. Future research is therefore needed to determine the applicability of the measurement instrument in different rugby player populations. Furthermore, given the fact that no other decision-making measurement instruments have been developed for use in the South African rugby context, the results of this study can not be compared to any other results.

Given the self-report nature of the measurement instrument, it would be of value for further research to be done in order to construct a similar instrument to be completed by individuals other than the players, for example coaches. This instrument can be used for comparing the self-reported decision-making scores of players with those of outside observers in an effort to obtain a score that is less influenced by possible player overconfidence.

Lastly, as the focus of this study was solely on the decision-making abilities of expert rugby players, it is uncertain to what extent these findings can be generalized to sporting codes outside of rugby union. Further studies should look at the applicability of the measurement instrument developed in this study in other team sport contexts. Variations on the study can also be made in order to study the decision-making abilities and shortcomings of athletes taking part in individual sports, for example golf, athletics and, to a certain extent, cricket, to name just a few.

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8. APPENDIXES

APPENDIX A

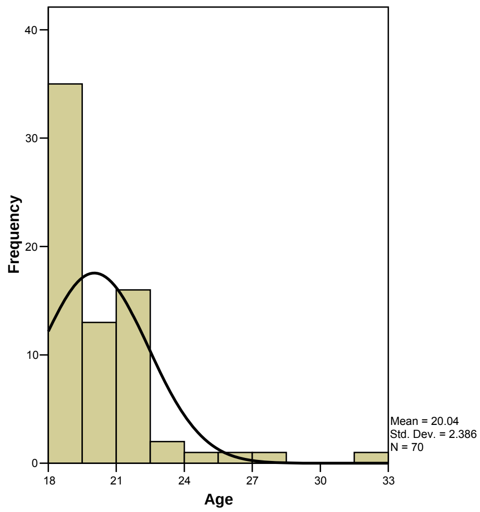
QUESTIONNAIRE

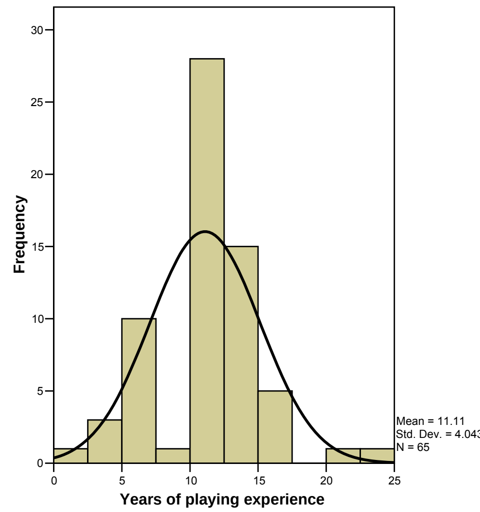
Consent form completed	Y / N	/1
Please give an indication of your preferred playing position (Write only your playing number)		/2
Age		/3
Years of playing experience (How long have you been playing rugby?)		/4
Highest playing level achieved (Circle only one option)	1. First team at school 2. Provincial school rugby (E.g. Craven Week) 3. Club rugby (E.g. Carlton Cup) 4. Provincial age group rugby (o/19, o/21) 5. Vodacom Cup 6. Currie Cup 7. Higher	/5

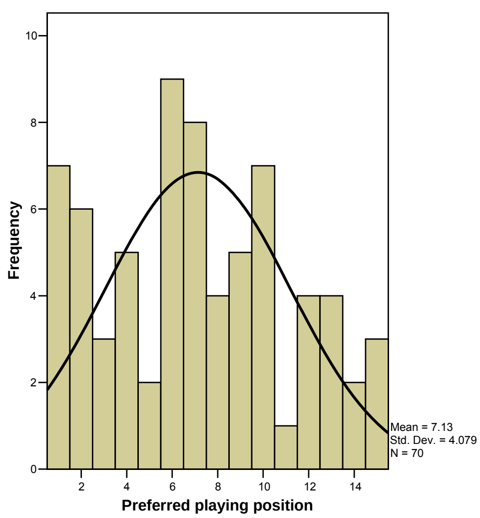
	Poor	Below average	Good	Very good	Excellent	
1. When in possession of the ball, my ability to look for open space is	1	2	3	4	5	/6
2. During matches my ability to look not only at the ball, but also over the field is	1	2	3	4	5	/7
3. I can quickly identify the weak points of my opponents	1	2	3	4	5	/8
4. When in I am in defense, I know quickly what my opponent is going to do	1	2	3	4	5	/9
5. If our team loses ball possession during a match, I quickly switch to my task as defender	1	2	3	4	5	/10
6. When on defense, I can quickly identify where the attacking players are	1	2	3	4	5	/11
7. If I posses the ball, I know exactly to whom I have to pass	1	2	3	4	5	/12
8. If a teammate receives the ball, I know exactly what he is going to do	1	2	3	4	5	/13
9. Without looking at only one player, I know where my opponent's are moving to	1	2	3	4	5	/14
10. If our team get turnover ball, my support play is generally	1	2	3	4	5	/15
11. During matches my ability to follow the ball is	1	2	3	4	5	/16
12. I apply my knowledge of the rules of the game accurately to matches	1	2	3	4	5	/17
13. I am good at making the right decisions at the right moments	1	2	3	4	5	/18
14. I am accurate about predicting what is going to happen next in a match	1	2	3	4	5	/19
15. When on attack, I know how to get into open space during a match	1	2	3	4	5	/20
16. If an opponent receives the ball, I know exactly what he is going to do	1	2	3	4	5	/21
17. When in possession of the ball, my ability to look for the defenders is	1	2	3	4	5	/22
18. I am generally able to make quick on-field decisions	1	2	3	4	5	/23
19. Compared to other players, my playing within the laws of the game is	1	2	3	4	5	/24
20. If my team receives the ball I know exactly what to do	1	2	3	4	5	/25
21. My overview of the game, whether in defense or possession is	1	2	3	4	5	/26
22. My ability to react quickly from defending to being in possession of the ball is	1	2	3	4	5	/27
23. When in defense of a second or later phase, I know exactly which position to take	1	2	3	4	5	/28
24. When in possession of the ball, I can quickly identify where the defenders are	1	2	3	4	5	/29
25. When in defense, my ability to focus on opponents in my defensive channel is	1	2	3	4	5	/30
26. If I receive the ball from a teammate, I know in advance where to move the ball	1	2	3	4	5	/31
27. When in defense of a first phase, I know exactly which position to take	1	2	3	4	5	/32
28. When in defense, my ability to focus on the ball is	1	2	3	4	5	/33
29. When in possessions of the ball, I can quickly predict what the defense is going to do	1	2	3	4	5	/34
30. I have the ability to take actions on the field that lead to positive results for my team	1	2	3	4	5	/35
31. While executing an action in a match, I know exactly what I will have to do next	1	2	3	4	5	/36
32. When in possession of the ball, my ability to look for supporting players is	1	2	3	4	5	/37
33. My positioning during a match is generally	1	2	3	4	5	/38
34. I know exactly when to pass the ball to a teammate or when not to	1	2	3	4	5	/39
35. If our team loses ball possession, I know exactly what to do	1	2	3	4	5	/40
36. When in I am on attack, I know quickly what my opponent is going to do	1	2	3	4	5	/41
37. I quickly react to rectify mistakes of my teammates	1	2	3	4	5	/42
38. When I receiving the ball, I do not have to look where my teammates are, I already know	1	2	3	4	5	/43
39. When in defense, my ability to focus on opponents outside of my defensive channel is	1	2	3	4	5	/44
40. In general, please give an indication of your overall skill-level as a rugby player	1	2	3	4	5	/45

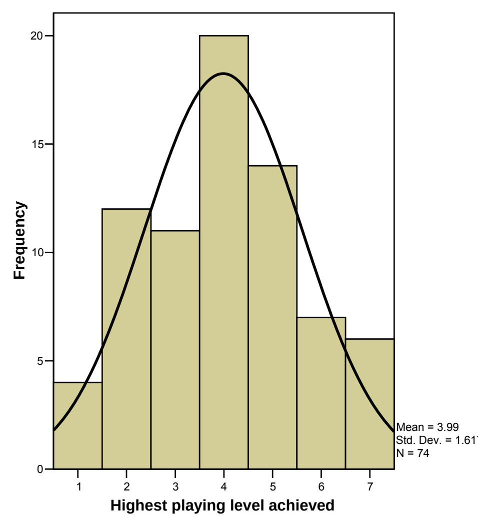
APPENDIX B

HISTOGRAMS SHOWING THE DISTRIBUTION OF DEMOGRAPHIC INFORMATION OF PARTICIPANTS



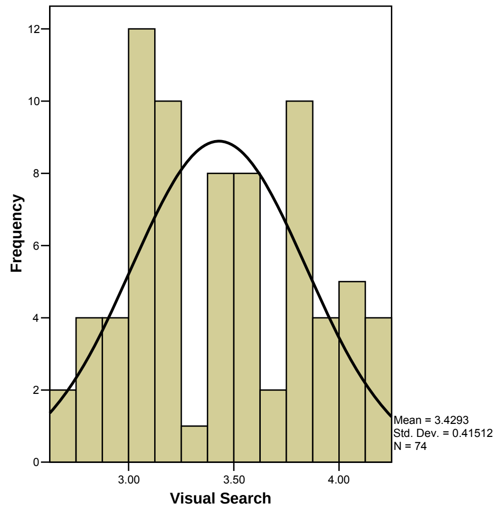


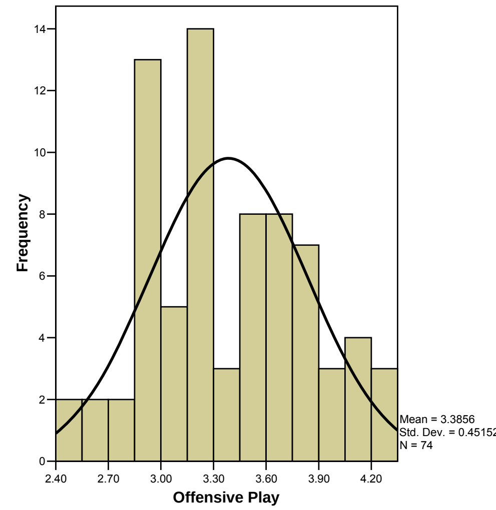


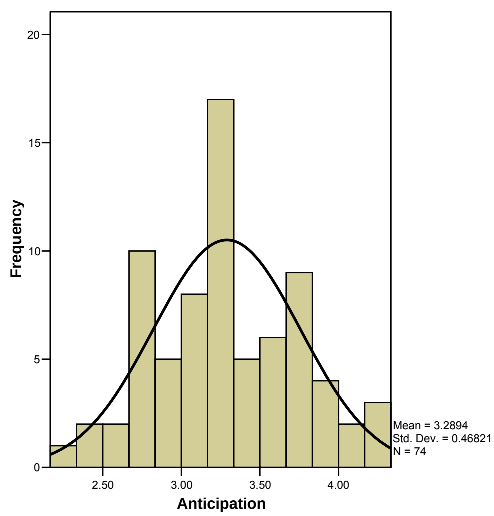


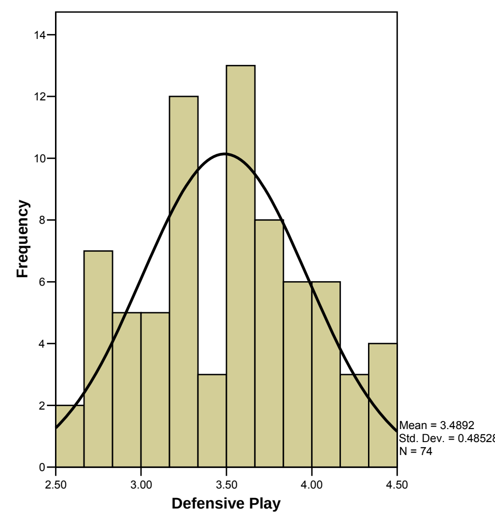
APPENDIX C

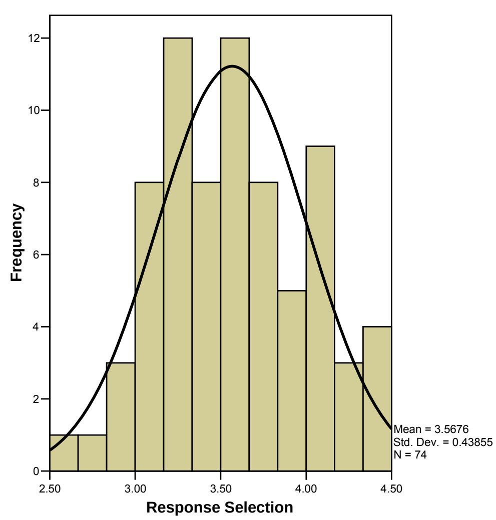
HISTOGRAMS SHOWING THE DISTRIBUTION OF SUMMARY SCORES

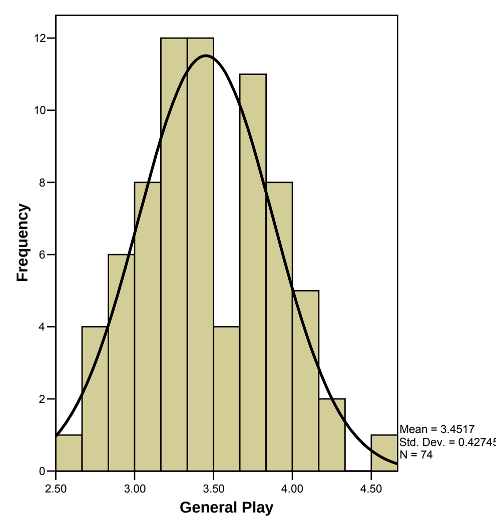












SPLIT-HALF RELIABILITY ANALYSIS

Reliability Statistics

Cronbach's Alpha	Part 1	Value	.866
		N of Items	20[a]
	Part 2	Value	.883
		N of Items	20[b]
	Total N of Items		40
Correlation Between Forms			.768
Spearman-Brown Coefficient	Equal Length		.869
	Unequal Length		.869
Guttman Split-Half Coefficient			.869

a. The items are: When in possession of the ball, my ability to look for open space is, During matches my ability to look not only at the ball, but also over the field is, I can quickly identify the weak points of my opponents, When in I am in defense, I know quickly what my opponent is going to do, If our team loses ball possession during a match, I quickly switch to my task as defender, When on defense, I can quickly identify where the attacking players are, If I posses the ball, I know exactly to whom I have to pass, If a teammate receives the ball, I know exactly what he is going to do, Without looking at only one player, I know where my opponent's are moving to, If our team get turnover ball, my support play is generally, During matches my ability to follow the ball is, I apply my knowledge of the rules of the game accurately to matches, I am good at making the right decisions at the right moments, I am accurate about predicting what is going to happen next in a match, When on attack, I know how to get into open space during a match, If an opponent receives the ball, I know exactly what he is going to do, When in possession of the ball, my ability to look for the defenders is, I am generally able to make quick on-field decisions, Compared to other players, my playing within the laws of the game is, If my team receives the ball I know exactly what to do.

b. The items are: My overview of the game, whether in defense or possession is, My ability to react quickly from defending to being in possession of the ball is, When in defense of a second or later phase, I know exactly which position to take, When in possession of the ball, I can quickly identify where the defenders are, When in defense, my ability to focus on opponents in my defensive channel is, If I receive the ball from a teammate, I know in advance where to move the ball, When in defense of a first phase, I know exactly which position to take, When in defense, my ability to focus on the ball is, When in possessions of the ball, I can quickly predict what the defense is going to do, I have the ability to take actions on the field that lead to positive results for my team, While executing an action in a match, I know exactly what I will have to do next, When in possession of the ball, my ability to look for supporting players is , My positioning during a match is generally, I know exactly when to pass the ball to a teammate or when not to, If our team loses ball possession, I know exactly what to do, When in I am on attack, I know quickly what my opponent is going to do, I quickly react to rectify mistakes of my teammates, When I receiving the ball, I do not have to look where my teammates are, I already know, When in defense, my ability to focus on opponents outside of my defensive channel is, In general, please give an indication of your overall skill-level as a rugby player.

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MULTIPLE COMPARISON ANALYSIS OF SUMMARY SCORES BY PREFERRED PLAYING POSITION (GROUPED)

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Preferred playing position	(J) Preferred playing position	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Visual Search	Tight_Five	Loose_Trio	.01386	.12346	.993	-.2821	.3098
		Backline	.18588	.11709	.258	-.0948	.4665
	Loose_Trio	Tight_Five	-.01386	.12346	.993	-.3098	.2821
		Backline	.17202	.12002	.330	-.1156	.4597
	Backline	Tight_Five	-.18588	.11709	.258	-.4665	.0948
		Loose_Trio	-.17202	.12002	.330	-.4597	.1156
Anticipation	Tight_Five	Loose_Trio	.04141	.13979	.953	-.2937	.3765
		Backline	.24470	.13258	.163	-.0731	.5625
	Loose_Trio	Tight_Five	-.04141	.13979	.953	-.3765	.2937
		Backline	.20330	.13589	.299	-.1224	.5290
	Backline	Tight_Five	-.24470	.13258	.163	-.5625	.0731
		Loose_Trio	-.20330	.13589	.299	-.5290	.1224
Response Selection	Tight_Five	Loose_Trio	.19033	.12944	.312	-.1199	.5006
		Backline	.34221*	.12277	.019	.0480	.6365
	Loose_Trio	Tight_Five	-.19033	.12944	.312	-.5006	.1199
		Backline	.15188	.12583	.453	-.1497	.4535
	Backline	Tight_Five	-.34221*	.12277	.019	-.6365	-.0480
		Loose_Trio	-.15188	.12583	.453	-.4535	.1497
Offensive Play	Tight_Five	Loose_Trio	.10890	.13415	.697	-.2126	.4304
		Backline	.18473	.12722	.321	-.1202	.4897
	Loose_Trio	Tight_Five	-.10890	.13415	.697	-.4304	.2126
		Backline	.07582	.13040	.830	-.2367	.3884
	Backline	Tight_Five	-.18473	.12722	.321	-.4897	.1202
		Loose_Trio	-.07582	.13040	.830	-.3884	.2367
Defensive Play	Tight_Five	Loose_Trio	-.02029	.14089	.989	-.3580	.3174
		Backline	.32458*	.13362	.046	.0043	.6449
	Loose_Trio	Tight_Five	.02029	.14089	.989	-.3174	.3580
		Backline	.34487*	.13696	.037	.0166	.6731
	Backline	Tight_Five	-.32458*	.13362	.046	-.6449	-.0043
		Loose_Trio	-.34487*	.13696	.037	-.6731	-.0166
General Play	Tight_Five	Loose_Trio	.13650	.12823	.539	-.1709	.4439
		Backline	.29479*	.12162	.047	.0033	.5863
	Loose_Trio	Tight_Five	-.13650	.12823	.539	-.4439	.1709
		Backline	.15829	.12465	.417	-.1405	.4571
	Backline	Tight_Five	-.29479*	.12162	.047	-.5863	-.0033
		Loose_Trio	-.15829	.12465	.417	-.4571	.1405
Decision-making Total	Tight_Five	Loose_Trio	.08186	.12064	.777	-.2073	.3710
		Backline	.25760	.11442	.070	-.0167	.5318
	Loose_Trio	Tight_Five	-.08186	.12064	.777	-.3710	.2073
		Backline	.17573	.11728	.298	-.1054	.4568
	Backline	Tight_Five	-.25760	.11442	.070	-.5318	.0167
		Loose_Trio	-.17573	.11728	.298	-.4568	.1054

*. The mean difference is significant at the .05 level.

REGRESSION ANALYSIS OF SUMMARY SCORES AND OVERALL SKILL LEVEL

Variables Entered/Removed[a,b]

Model	Variables Entered	Variables Removed	Method
1	Response Selection	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: 40. In general, please give an indication of your overall skill-level as a rugby player

b. Linear Regression through the Origin

Model Summary

Model	R	R Square[a]	Adjusted R Square	Std. Error of the Estimate
1	.984[b]	.968	.967	.684

a. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

b. Predictors: Response Selection

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	Response Selection	1.037	.022	.984	46.928	.000

a. Dependent Variable: 40. In general, please give an indication of your overall skill-level as a rugby player

b. Linear Regression through the Origin

ANOVA[c,d]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1028.895	1	1028.895	2202.268	.000[a]
	Residual	34.105	73	.467		
	Total	1063.000[b]	74			

a. Predictors: Response Selection

b. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

c. Dependent Variable: 40. In general, please give an indication of your overall skill-level as a rugby player

d. Linear Regression through the Origin

Excluded Variables[b,c]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Visual Search	.372[a]	1.447	.152	.168	.007
	Anticipation	.132[a]	.579	.565	.068	.008

a. Predictors in the Model: Response Selection

b. Dependent Variable: 40. In general, please give an indication of your overall skill-level as a rugby player

c. Linear Regression through the Origin

RESPONSE VARIATIONS EXPLAINED BY THE 6 IDENTIFIED FACTORS

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.588	27.149	27.149	10.588	27.149	27.149	3.931	10.081	10.081
2	2.371	6.080	33.229	2.371	6.080	33.229	3.801	9.745	19.826
3	2.171	5.565	38.794	2.171	5.565	38.794	3.526	9.042	28.868
4	1.957	5.017	43.811	1.957	5.017	43.811	3.497	8.966	37.834
5	1.784	4.576	48.387	1.784	4.576	48.387	3.072	7.876	45.710
6	1.561	4.003	52.389	1.561	4.003	52.389	2.605	6.679	52.389
7	1.446	3.708	56.097						
8	1.412	3.622	59.719						
9	1.222	3.133	62.852						
10	1.181	3.028	65.880						
11	1.102	2.825	68.704						
12	1.075	2.755	71.460						
13	.980	2.512	73.972						
14	.972	2.493	76.465						
15	.883	2.264	78.729						
16	.765	1.962	80.691						
17	.715	1.834	82.525						
18	.674	1.728	84.253						
19	.651	1.668	85.921						
20	.545	1.398	87.319						
21	.490	1.257	88.576						
22	.478	1.227	89.803						
23	.449	1.150	90.953						
24	.426	1.093	92.046						
25	.363	.932	92.978						
26	.348	.892	93.870						
27	.329	.844	94.714						
28	.298	.764	95.479						
29	.260	.668	96.146						
30	.248	.635	96.782						
31	.215	.552	97.333						
32	.207	.530	97.864						
33	.171	.440	98.303						
34	.167	.428	98.731						
35	.137	.352	99.084						
36	.126	.323	99.406						
37	.094	.240	99.646						
38	.079	.203	99.849						
39	.059	.151	100.000						

Extraction Method: Principal Component Analysis.

ALLOCATION OF ITEMS TO COMPONENTS IDENTIFIED BY FACTOR ANALYSIS

Rotated Component Matrix[a]

	Component					
	1	2	3	4	5	6
1. When in possession of the ball, my ability to look for open space is			.375			
2. During matches my ability to look not only at the ball, but also over the field is				.623		
3. I can quickly identify the weak points of my opponents				.367		
4. When in I am in defense, I know quickly what my opponent is going to do	.542					
5. If our team loses ball possession during a match, I quickly switch to my task as defender	.758					
6. When on defense, I can quickly identify where the attacking players are			.629			
7. If I posses the ball, I know exactly to whom I have to pass			.618			
8. If a teammate receives the ball, I know exactly what he is going to do			.601			
9. Without looking at only one player, I know where my opponent's are moving to		.492				
10. If our team get turnover ball, my support play is generally	.577					
11. During matches my ability to follow the ball is	.585					
12. I apply my knowledge of the rules of the game accurately to matches					.715	
13. I am good at making the right decisions at the right moments			.528			
14. I am accurate about predicting what is going to happen next in a match				.587		
15. When on attack, I know how to get into open space during a match			.452			
16. If an opponent receives the ball, I know exactly what he is going to do			.413			
17. When in possession of the ball, my ability to look for the defenders is						.728
18. I am generally able to make quick on-field decisions					.486	
19. Compared to other players, my playing within the laws of the game is					.474	
20. If my team receives the ball I know exactly what to do					.479	
21. My overview of the game, whether in defense or possession is				.477		
22. My ability to react quickly from defending to being in possession of the ball is						.470
23. When in defense of a second or later phase, I know exactly which position to take	.611					
24. When in possession of the ball, I can quickly identify where the defenders are						.776
25. When in defense, my ability to focus on opponents in my defensive channel is	.398					
26. If I receive the ball from a teammate, I know in advance where to move the ball				.454		
27. When in defense of a first phase, I know exactly which position to take		.498				
28. When in defense, my ability to focus on the ball is					.465	
29. When in possessions of the ball, I can quickly predict what the defense is going to do				.523		
30. I have the ability to take actions on the field that lead to positive results for my team				.499		
31. While executing an action in a match, I know exactly what I will have to do next		.541				
32. When in possession of the ball, my ability to look for supporting players is		.683				
33. My positioning during a match is generally		.671				
34. I know exactly when to pass the ball to a teammate or when not to		.428				
35. If our team loses ball possession, I know exactly what to do		.419				
36. When in I am on attack, I know quickly what my opponent is going to do				.505		
37. I quickly react to rectify mistakes of my teammates					.726	
38. When I receiving the ball, I do not have to look where my teammates are, I already know				.533		
39. When in defense, my ability to focus on opponents outside of my defensive channel is	.494					

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 15 iterations.

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FINAL DECISION-MAKING QUALITY MEASUREMENT INSTRUMENT

Consent form completed	Y / N	/1
Please give an indication of your preferred playing position (Write only your playing number)		/2
Age		/3
Years of playing experience (How long have you been playing rugby?)		/4
Highest playing level achieved (Circle only one option)	1. First team at school 2. Provincial school rugby (E.g. Craven Week) 3. Club rugby (E.g. Carlton Cup) 4. Provincial age group rugby (o/19, o/21) 5. Vodacom Cup 6. Currie Cup 7. Higher	/5

Please give an indication of your ability to take each of the following actions during a match.
Compare your own ability to the best player in your position you have ever played against and rate yourself compared to that player.

	Poor	Below average	Good	Very good	Excellent	
1. When in possession of the ball, my ability to look for open space is	1	2	3	4	5	/6
2. During matches my ability to look not only at the ball, but also over the field is	1	2	3	4	5	/7
3. I can quickly identify the weak points of my opponents	1	2	3	4	5	/8
4. When in I am in defense, I know quickly what my opponent is going to do	1	2	3	4	5	/9
5. When on defense, I can quickly identify where the attacking players are	1	2	3	4	5	/11
6. If I posses the ball, I know exactly to whom I have to pass	1	2	3	4	5	/12
7. If a teammate receives the ball, I know exactly what he is going to do	1	2	3	4	5	/13
8. Without looking at only one player, I know where my opponent's are moving to	1	2	3	4	5	/14
9. During matches my ability to follow the ball is	1	2	3	4	5	/16
10. I apply my knowledge of the rules of the game accurately to matches	1	2	3	4	5	/17
11. I am good at making the right decisions at the right moments	1	2	3	4	5	/18
12. I am accurate about predicting what is going to happen next in a match	1	2	3	4	5	/19
13. When on attack, I know how to get into open space during a match	1	2	3	4	5	/20
14. If an opponent receives the ball, I know exactly what he is going to do	1	2	3	4	5	/21
15. When in possession of the ball, my ability to look for the defenders is	1	2	3	4	5	/22
16. I am generally able to make quick on-field decisions	1	2	3	4	5	/23
17. Compared to other players, my playing within the laws of the game is	1	2	3	4	5	/24
18. If my team receives the ball I know exactly what to do	1	2	3	4	5	/25
19. My overview of the game, whether in defense or possession is	1	2	3	4	5	/26
20. My ability to react quickly from defending to being in possession of the ball is	1	2	3	4	5	/27
21. When in defense, my ability to focus on opponents in my defensive channel is	1	2	3	4	5	/30
22. If I receive the ball from a teammate, I know in advance where to move the ball	1	2	3	4	5	/31
23. When in defense of a first phase, I know exactly which position to take	1	2	3	4	5	/32
24. I have the ability to take actions on the field that lead to positive results for my team	1	2	3	4	5	/35
25. While executing an action in a match, I know exactly what I will have to do next	1	2	3	4	5	/36
26. When in possession of the ball, my ability to look for supporting players is	1	2	3	4	5	/37
27. My positioning during a match is generally	1	2	3	4	5	/38
28. I know exactly when to pass the ball to a teammate or when not to	1	2	3	4	5	/39
29. If our team loses ball possession, I know exactly what to do	1	2	3	4	5	/40
30. When in I am on attack, I know quickly what my opponent is going to do	1	2	3	4	5	/41
31. I quickly react to rectify mistakes of my teammates	1	2	3	4	5	/42
32. When I receiving the ball, I do not have to look where my teammates are, I already know	1	2	3	4	5	/43
33. When in defense, my ability to focus on opponents outside of my defensive channel is	1	2	3	4	5	/44
34. In general, please give an indication of your overall skill-level as a rugby player	1	2	3	4	5	/45

INFORMED CONSENT FORM

The purpose of this informed consent form is to inform you about the research study in which you may choose to participate. It also serves to formally obtain your permission to use the information provided during this study for the purpose of analysis.

The name of this study is **“Assessing the quality of decision-making of expert rugby players”**. This research is aimed at developing an inventory that measures the self-reported quality of the on-field decision-making of expert rugby players.

To uncover the most important aspects of quality on-field decision-making, you will be required to anonymously complete a close-ended questionnaire. You will be required to complete each of the items as accurately as possible with regards to your personal skill-level. With your permission the researcher will retain the completed questionnaire for the purpose of further analysis.

Please note:

- You are not obligated to take part in this research and you may withdraw at any time.
- The information provided will be handled in an anonymous and confidential manner and the raw data will not be viewed by anyone except the researcher, Mr. P. J. Claasen.
- If you have any concerns about this research, please ask the researcher for further clarification.

Declaration:

I, ________________ have read and understand this form.

By signing this form, I choose to participate in this research project and I understand that the information will be used for further analysis. I further understand that this information may be published.

____________________ ____________________

Signature of participant **Date**

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Place

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Thank you very much for your participation, it is greatly appreciated. All the best for your rugby career.