THE IMPACT OF AN INTERVENTION PROGRAMME ON THE DECISION MAKING SPEED AND ACCURACY, DECLARATIVE KNOWLEDGE, AND SELECTED VISUAL SKILLS OF U/20 RUGBY PLAYERS

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Declaration

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Abstract

The purpose of this study was to determine the effectiveness of a 16-week multi-dimensional intervention programme on the speed and accuracy of decision making, declarative knowledge and visual skills of u/20 rugby players. Two intact groups of rugby academy players participated in this study. One academy group participated in the intervention programme, which included activities, including the statistical analysis of individual players, game analysis, tactical rugby discussions, rugby rule discussions and visual skills training. The other academy group served as the comparison group and completed both the pre- and post-tests.

The results indicated significant improvements in the speed of tactical decision making by participants in both the experimental and the comparison groups. Both groups also indicated a significant deterioration in the accuracy of their decisions. Both groups achieved a significant improvement in their declarative knowledge of rugby rules, as well as in their visual skills. The similarity in the post-test scores of the two groups led to the conclusion that the intervention programme, as presented in this study, did not appear to make a significant impact on the players. Suggestions are made for the design of future intervention programmes to improve tactical decision making.

Abstrak

Die doel van hierdie studie was om die effektiwiteit van ‘n 16-weeklange multi-dimensionele intervensieprogram op die spoed en akkuraatheid van besluitneming, verklarende kennis en visuele vaardighede van o/20 rugbyspelers te bepaal. Twee groepe spelers van ‘n rugby akademie het aan die studie deelgeneem. Een groep het aan die intervensieprogram deelgeneem wat aktiwiteite soos statistiese analise van individuele spelers, spelontleding, taktiese rugby besprekings, bespreking van rugbyreëls en visuele vaardigheidsopleiding ingesluit het. Die tweede groep het as die vergelykende groep opgetree wat beide die pre- en post-toetse voltooi het.

Die resultate het beduidende verbeterings in die spoed van taktiese besluitneming in deelnemers van beide die eksperimentele en vergelykende groepe getoon. Beide groepe het ook ‘n beduidende agteruitgang in die akkuraatheid van hulle besluite getoon. Beide groepe het ‘n beduidende verbetering in hulle verklarende kennis van rugby asook visuele vaardighede getoon. Na aanleiding van die ooreenkomste in die post-toetsresultate van die twee groepe is die afgeleiding gemaak dat die intervensieprogram, soos in die studie voorgestel, nie blyk asof dit ‘n beduidende impak op die spelers het nie. Voorstelle word gemaak vir die ontwerp van toekomstige intervensieprogramme om taktiese besluitneming te verbeter.

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Chapter 1
Setting the Problem

Decision making in team sports involves the ability to make quick and accurate tactical decisions, and has been identified as one of the most important aspects of successful performance (Tavares, 1997). According to Crouch (1992) players need to be quick-thinking because they are required to make fast and accurate decisions in ever-changing situations. Whether players are on attack or defense, they need to solve a variety of problems.

Strategy has been defined as the overall plan for gaining advantage over opponents during a game, and tactics are the specific actions taken to fulfill this plan. Greenwood (2000) described tactical training as the methods through which players learn to read game situations in order to respond with offensive and defensive actions to fulfill strategic objectives. He suggested that tactical training could include tasks such as studying the principles of sport strategy, studying the rules and regulations, analysing the patterns of play of future opponents, analysing one's own team and individual performance, etc. He summarised the advantages of tactical training to be the following:

- Players become confident when they practice and train different forms of offence and defense because they feel that they have options to choose from.
- Players learn to associate certain cues with certain options, which means they will experience more success in their performance.
- Players learn to see offence as a sequence of attacking moves and phases of play in which they "chunk" information, thus increasing the speed at which they can make decisions.
- Players improve their timing skills when creating space.
- Players learn about the advantages of playing their positions as part of a bigger offensive or defensive plan.
- Players realise that success in the execution of any play often relies on timing

and the rhythm of the interaction among teammates.

Bompa (1999) noted that tactical training must incorporate the development of the skill techniques and physical fitness needed to implement tactical decisions. This association between skill and tactics has been demonstrated in research on rugby. Seyers and Washington-King (2005) analysed 48 games in the 2003 Super 12 Rugby competition (including six different teams and 90 players) in order to identify the characteristics of effective ball carries. The following results demonstrated the relationship between skills and tactics when carrying the ball effectively during game play:

- In Terms of Receiving the Ball

  Players on top teams received the ball at a significantly faster speed than those on the bottom teams. This highlighted the importance of teams training at a very high intensity when passing, receiving and then carrying the ball if they are to execute tactical moves effectively under pressure.

- In Terms of Running Speed

  Players on top teams ran with the ball much faster than players on the bottom teams. The authors concluded that a player's running speed and acceleration form the basis of effective ball carrying in rugby.

- In Terms of Attackers

  Attackers rarely ran straight towards their defenders and when they did, they were less successful. The most common successful running path was found to be an oblique one where the attacker ran slightly to the side, with his shoulder off the defender. The authors observed that oblique running takes some of the control of the contact away from the defender and also leaves more decisions for the defender to make, which is why it may be the most successful path.

- In Terms of Evasive Actions

  The most common evasive action was a simple forward step. It was highlighted that a forward step broke more tackles and enabled the ball carrier to maintain forward momentum.

> Backs broke twice as many tackles and were missed by tacklers five times more than forwards. This was explained by noting the speed backs ran, the speed at which they received their passes and the space they have available to run angles at their defenders. All of these factors made it more difficult for a defender to decide when and how to tackle a back, compared to a forward.

This research illustrated how important it is that ball carriers learn to make decisions while running with great intensity and without decelerating during impact (Greenwood, 2000). A wing needs to have good hands (ball-handling skill), speed, good visual skills to counter-attack and excellent tackling skills, and be able to kick with either foot. A centre, on the other hand, must have good ball-handling skills to pass with either hand as well as having a variation in passes in order to get good passes to wings and fullbacks (Greenwood, 2000). Greenwood (2000) identified the fly half as the leader of the backline who must make many decisions. In addition to reading the whole pattern of the game and calling the tactical plays, the fly half must have quick hands and the ability to place tactical kicks.

Because the acquisition of skills and tactics are critical in the preparation of rugby players, there are constant efforts to discover methods to improve skill and tactical performance. Different coaching methods have been found to make different contributions to these efforts. Two methodological approaches will be discussed briefly in the sections below: the “Game Sense” approach and the cognitive processing approach.

The Game Sense Approach

The Game Sense approach is also called the “Games for Understanding” approach (Turner & Martinek, 1995). It is based on participation in mini-game situations that are usually structured in the following sequence:

1. Initial participation in the mini-game.
2. Emphasis on understanding the rules of the mini-game (should reflect some of the rules that govern the formal sport that is the ultimate target for learning).
3. Development of tactical awareness as the coach stops play and either the coach or the players point out spaces and tactical opportunities, both on offence and defense.

4. Focus on decision making where the players discuss what to do and how to do it. The ability to recognise cues and predict potential outcomes is encouraged by stopping play and discussion around “what just happened” and why, followed by a “what if” exploration of other options.

5. Emphasis on skill execution as the mini-game is played for sustained periods of time and feedback on technical proficiency is provided by the coach.

6. Transfer of proficiencies learned in the mini-game to a more complicated mini-game and finally to the full version of the sport.

The questions put to players during the game sense approach are usually directed to the tactical aspects of the game. The coach guides the discussion so that the players discover the optimal solutions themselves, rather than waiting for the coach to tell them the answer (Den Duyn, 1996). The improvement of decision making in this approach is proposed to be related to the development of strategic knowledge (Farrow & Jones, 1999). The discussions with the players about what they observed in certain situations are believed to contribute to a player’s knowledge development.

The Cognitive Processing Approach

Abernethy (1996) advocated the use of motor control theory to find methods to enhance sport performance. He recommended the adoption of the information-processing model of motor skill performance, which comprises three sequential processes: perception, decision making and movement execution, which would put an emphasis on the systematic training of perception and decision making. His research indicated that, especially in ball sports, perception and decision making are more likely to act as the limiting factors to successful performance than are the technical aspects of motor skill execution.

The information processing model is based on the assumption that humans produce skilled movements by cognitively processing information in the central nervous system (Abernethy, 1991). A study by Kioumourtzoglou, Michalopoulou, Kourtessis and Kourtessis (1998) examined the relationship between cognitive abilities and athletic excellence in different ball games. They found that there were definite differences between the cognitive abilities of expert players and novice players. Expert players had the ability to perceive large and meaningful patterns, they were faster to identify patterns (which gave them more time to analyse situations) and they were better able to organise their knowledge and use it effectively. They could also recall situations more accurately and use early cues better than novices.

Adopting a cognitive processing approach means that the processes of perception and decision making would be targeted for improvement during intervention programmes. This would include developing an enhanced knowledge base as well as the training of perceptual skills, such as visual search. Ripoll and Benguigui (1999) were convinced that part of ball sport expertise is linked to the development of perceptual-motor coupling. The enhanced cognitive knowledge base needed to achieve successful perceptual-motor coupling appears to be developed as a result of years of sport-specific experience. A challenge to sport scientists is to find viable alternatives to years of task-specific practice – to find alternative training methods that could be used to enhance the development of perceptual skill in sport at a faster rate (Abernethy, 1993). Perceptual skills such as pattern recognition use visual search strategies to find cues that allow anticipation (Starkes & Ericsson, 2003). One option for improving perceptual skills is to attempt to enhance the different visual skills in order to enhance visual search. It may be possible that improvements in the speed and accuracy of visual search could contribute positively to decision-making speed and accuracy.

Purpose of the Study

The purpose of this study was to follow the cognitive processing approach and examine the effectiveness of specific perceptual and cognitive methods for developing tactical understanding in rugby. Specifically, the study assessed the impact of a multi-dimensional intervention programme to improve the speed and accuracy of tactical decision making, as well as the declarative knowledge and the selected visual skills of u/20 rugby players. It was hoped that insight would be gained into the effectiveness of the following methods when used together in a rugby training programme:

1. Statistical analysis of individual players
2. Game analysis
3. Tactical rugby discussions

4. Rugby rule discussions
5. Field-based visual skills training

Significance of the Study

Research has not yet determined how to best structure either cognitive or perceptual training programmes to enhance decision making (Williams & Grant, 1999). Coaches are concerned with teaching players how to read and respond/act to situations in competition in order to gain a tactical advantage over his/her opponent. They are looking for intervention programmes that will work. The effect of sports vision training on sport performance is still under debate. Some researchers claim that it leads to improved visual skills that in turn will have a positive impact on the speed and accuracy of perception. Tavares (1997) concluded that the quality of information for decision making is highly dependent on players' visual skills.

Sport science has the responsibility to help coaches develop intervention programmes that will work. Sport science has yet to respond fully to this need for practical methods to develop tactical expertise. McMorris (1999) noted that there is a lack of research in the area of training decision making in sport, although it is known that decision making in a game is closely related to perception and tactical knowledge. Very few studies have attempted to determine, for example, whether perceptual capabilities can be enhanced through training (Williams & Grant, 1999).

It is very difficult to measure a player's decision-making ability in order to determine if a programme has had an effect on performance (McMorris, 1999). Attempts have been made to measure the accuracy of decision making by presenting slides of typical situations to players and then asking them what actions they would take if they were put in the same situation on court. Video clips of critical game situations have also been used to stimulate the development of the anticipation skills of players. Each player needs to process what they see, taking into account the ball, team members and opponents. At the beginning of this kind of training, players may need the coach's guidance in order to recognise what is important in the visual display, as well as to determine the appropriate decision and action to couple with that perception.

The significance of this study is that it examines the impact of a multi-dimensional intervention programme on the development of speed and accuracy in tactical decision making in rugby. Improvements in the accuracy of decision making have been reported in the sports-based research with novices in programmes where technical and strategic aspects of their sport were formally taught to players (French & Nevett, 1993). This study will also explore whether declarative knowledge and visual skills can be enhanced during the same intervention programme. One of the strategies in the intervention programme, computerised match analysis, has been used successfully to develop players' knowledge of situational or event possibilities (Williams & Davids, 1998). Video simulation has been used as an effective method of developing perceptual and decision-making expertise in selected sports (Williams & Grant, 1999).

Research Questions

The following research questions guided this research:

1. Will the speed and accuracy of decision making of u/20 rugby players be improved following participation in a 16-week programme designed to develop tactical understanding?

2. Will the declarative knowledge of u/20 rugby players be improved following participation in a 16-week programme designed to develop tactical understanding?

3. Will the visual skills of u/20 rugby players be improved following participation in a sports vision training programme, integrated into a programme designed to develop tactical understanding?

Methodology

This research is classified as a quasi-experimental nonequivalent control-group design. Two u/20 rugby academies volunteered to participate in this study. Both academies have full-time rugby programmes, play in the same league and have a staff of professional coaches. The intervention programme was implemented over a 16-week period with one of the academies, while the other academy served as the comparison group. The label comparison group is used instead of control group because it was not possible to control the programmes of the two academies to the degree that the only difference over 16 weeks was in the intervention programme. However, it was possible to ensure that the comparison group did not have access to the activities contained in the intervention programme delivered to the "experimental" group.

Limitations

When conducting any research in a real-world setting, practical limitations must be accepted. The following limitations were accepted as constraints in this study:

- Expert coaches were used to help design the assessment of speed and accuracy of decision making. While speed is a straightforward measurement, the identification of the correct or best option in a game situation may reflect bias toward certain game strategies. When scoring the accuracy of decision making, it is possible that the academy players were coming from a different strategic frame of reference than the experts whose judgment was taken to be "correct."

- The coach for the experimental group could select the critical incidents that became the focus for individual player analysis, game analysis and rugby tactics discussions that became part of the intervention programme. It cannot be guaranteed that the strategic direction of the discussions was consistent with the strategic direction of the assessment instrument.

- Although the two groups competed in the same league, they may have had very different tactical experiences during the season. Different weather conditions plus different match-ups between teams could have made for very different experiences.

- Some players in the experimental group were injured in the course of the season. While they could still participate in all discussions, the videotapes of the games would not have included their game performance since they were no longer playing. This could have modified the impact of the intervention programme on their post-test scores of decision-making speed and accuracy.

- The subjects were directed to make their decisions as quickly <u>and</u> accurately as possible. This meant that a quick choice led to a quick presentation of the next game situation. For some of the subjects, finishing the test quickly may have been attractive, and because their "score" on the test did not affect the status in the rugby academy, they may have been more concerned with speed than with accuracy.

- There was no feedback on whether or not an answer was correct. The accuracy score was not apparent to the subject and there was no option to change choices or to slow down and be more careful. During the test, selecting the wrong option did not "cost" the subject anything. During real-time situations in a rugby match, the "cost" of making a mistake can be very high.

Conclusion

Situations in team sports change quickly and continuously, thus team sports require a great number of tactical decisions by players. In research completed by Tavares (1997), the effect of experience on the quality and quickness of tactical decision-making time was studied using computer-based techniques. Players had to select the correct tactical alternative (pass, dribble or shoot) and respond by pressing a pre-selected key of the keyboard connected to the video computer. The accuracy and speed of a player's decision made during play was proposed to depend on factors such as information reception, tactical knowledge, motor skills and experience in interpreting situations. Results showed that expert players made quicker and more accurate decisions in tactical situations than novice players. Tavares (1997) concluded that as players become more skilful, the decision-making process becomes faster and the performance of the tactic or game plan is more successful. This study will explore a similar type of cognitive processing approach to improve the tactical decision making, declarative knowledge and visual skills of u/20 rugby players.

Chapter Two

Review of Literature

Among the many questions surrounding coaching practices are those associated with how coaches can help athletes develop a tactical understanding of their sport and how they can train athletes' ability to read the game (Abernethy, 1996). When watching a team sport, for example, some of the patterns of play may appear to be spontaneous reactions to a previous event. However, players who are trying to gain a tactical advantage over their opponents often purposefully create the continuously-changing situations on the field. In order to do this successfully, players need to make good decisions during the game as well as have the technical skills to carry out the chosen actions. Although it may seem that experienced players make the correct decisions and execute the correct actions more often than less-experienced players, this is not always the case. Players with years of experience may struggle in some situations to make and execute optimal decisions, and players who have been playing for only a few years have been known to be very effective in making tactical decisions and then taking actions. This has left coaches wondering about the degree to which they can improve tactical decision making through formal practice methods.

Rugby is a particularly challenging game that includes confrontation with the opposition as well as collaboration within the team of 15 players (Villepreux, 1993). Both teams want to gain possession of the ball and scoring is the result of the tactical coordination of individual and team efforts. Decision making can be identified as the heart of tactical play in rugby. Players who take the "wrong options" put their entire team in a difficult situation. Greenwood (2000) contended that some players have a "tactical talent" in which they seem to have a "natural ability" to spot the possibilities in a game and to respond to them more effectively than other players. Coaches, however, cannot count on having sufficient numbers of naturally talented decision makers – if indeed they do exist - and so they spend hours at practice teaching players learn how to make optimal decisions in game play.

This study can help coaches think about activities that they can use during the training year that may help them to improve the decision making of rugby players. To provide structure to this research, the review of previous literature is divided into four major sections, based on a general information processing model of decision making that is presented in Figure 1. The researcher formulated this special version of information processing in order to organise the complex review of literature complied for this study.

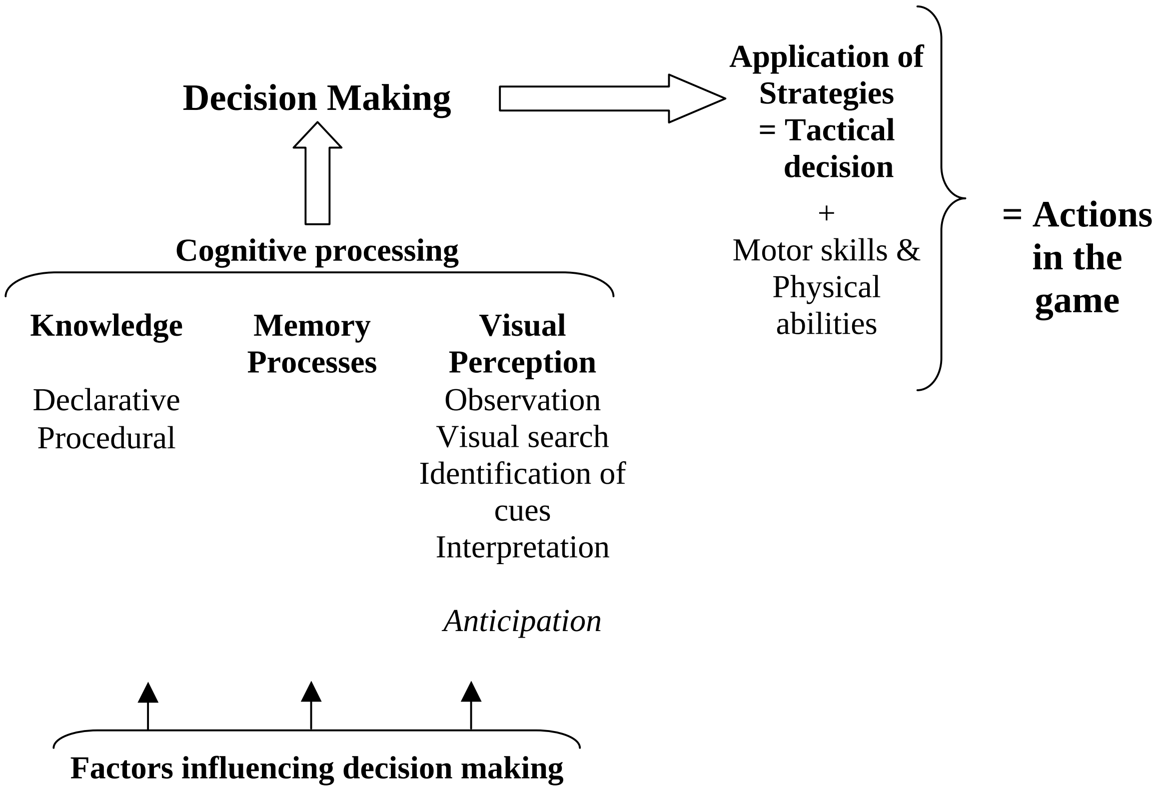

Figure 1

An information processing approach to understanding decision making in rugby

In this model, the actions performed in the game are the product of a player's tactical decision plus motor skills and physical abilities. The tactical decision is actually the application of a game strategy. The decision about the strategy-tactic to apply in the game is the result of decision making that relies on cognitive processing. Cognitive processing relies on perception, memory and knowledge. There are also additional factors that influence decision making that must be accounted for when designing training programmes. The organisation of this chapter follows these four sections:

1. Decision making, strategies and tactics

2. Cognitive processing as it supports decision making

3. Factors influencing decision making

4. Literature related to selected training programmes

Decision making, Strategies and Tactics

In her extensive review of the development of expertise and decision making in sport, Thomas (1994) found that motor learning research divided game performance into skill components (motor skills and physical abilities) and cognitive components (application of strategies and tactics). Game performance (actions taken in the game) was conceived to be the interaction between these two components. The portion of the information processing model that deals with decision making, strategies and tactics has been highlighted with a box in Figure 2.

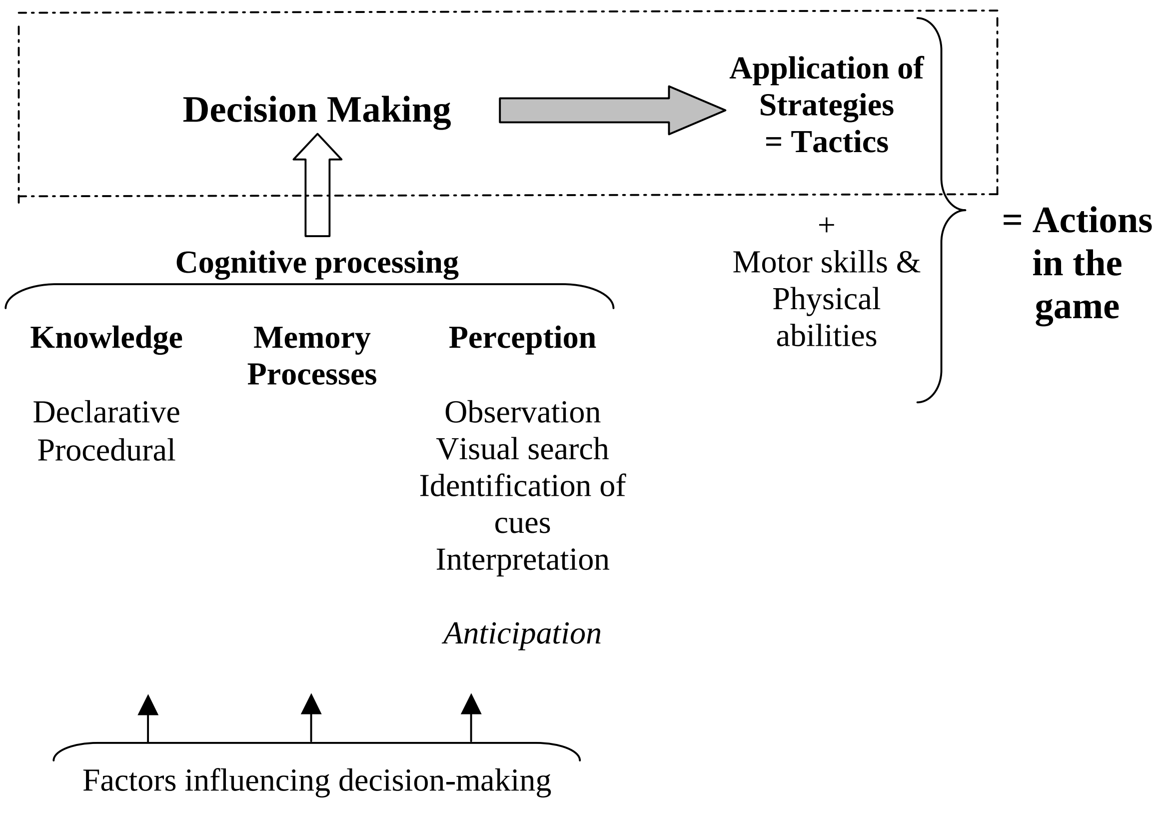

Figure 2

The relationship among decision making, strategies, tactics, motor skills and physical abilities

The initial consideration when making decisions is to identify which team has possession of the ball. This condition tells players that they are either on offence or on defense. When in personal control of the ball, a rugby player decides whether to run with it, pass it or kick it. If the player decides to pass it, he/she must determine to which teammate to pass, and when to pass the ball. If the opposition has possession and the player is defending, decisions must be made and actions taken to reduce the opportunities for the opponents to retain ball possession and/or score.

In rugby, decisions during game play must be made in an appropriate sequence and at the right time in response to the movement of teammates and opponents. Decisions are also influenced by the game score, the time period and the location of the players on the field. Smith (1984) divided the process of passing the ball in rugby into three phases, finding that the speed at which each phase is completed is related to the speed of the game:

1. A viewing phase when the player is in pursuit of the ball.
2. A decision phase where the player gains possession of the ball until the initiation of movement to pass it.
3. A ball pass phase from movement initiation until the ball leaves the hands of the player.

Strategies have been defined as a basic framework that guides decision making (Greenwood, 2000). A tactic is a practical application of a strategy. The successful application of a tactic involves performing the right skill at the right time on the field to achieve the general strategic objectives of the game. Strategies refer to the general game plan and are decided upon before the game starts. Gréhaigne, Godbout and Bouthier (1999) identified the fundamental difference between tactics and strategy to be one of time. Tactics operate under strict time constraints because decisions must be made and then implemented under pressure during game play. Strategies can involve carefully considered plans because decisions can be made without time constraints, since strategies are determined before a game begins.

Strategies

Evans, Horgan and James (1979) described strategic thinking in rugby as the art of planning how to use skills to gain fair advantage over an opponent. A team's strategy is an attempt to map out the course of a game and control the competitive tempo. At the elite level of competition, complex strategic planning will go into the preparation for a game. Gréhaigne *et al.* (1999) stated that strategy refers to the plans for the game discussed in advance in order for a team to coordinate their decisions during game play. According to Gréhaigne and Godbout (1995), strategy concerns:

- The general order for game play (*e.g.*, team composition, substitution plans).
- The positions and responsibilities to be covered during the game, given as instructions to each player prior to game play.

In high-strategy sports like rugby, football and basketball, constantly-changing situations compel players to constantly make decisions about what to do during different open skill situations. Decisions during high-strategy sports involve problem solving in dynamic situations where both cognitive and skill factors are critical to success.

Thomas (1994) proposed that sports could be put on a decision-making continuum, ranging from low-strategy sports on one end and high-strategy sports on the other end (see Figure 3).

- Low-strategy sports are those where success at the expert level is more dependent upon skill, fitness and other physical abilities, rather than proficiency in decision making and tactical performance. The strategies and tactics are not subject to severe time constraints which lower the challenge to speed of decision making. Technical execution should be the primary determinant of success at the top level in low strategy sports.
- High-strategy sports are those where fast and accurate decision making and tactical performance are essential for success. Skill, fitness and other physical abilities are very important, of course, but the difference among top players is in their ability to use their skills successfully at the right place and time to create a tactical advantage.

Based on the Thomas (1994) continuum, rugby can be classified as a high-strategy sport. This elevates the importance of tactics and tactical learning in practice sessions.

Low-Strategy Sports		**High-Strategy Sports**
Low time pressure on Decision Making	⟺	High time pressure on Decision Making
Example: Gymnastics	⟺	Example: Rugby
Decisions made prior to performance: Success depends primarily on skill execution and fitness.		Decisions made during performance: Success depends on speed and accuracy of decision making and tactical performance, as well as skill execution and fitness.

Figure 3

Low-strategy sports contrasted with high-strategy sports (based on Thomas, 1994)

Tactics

Tactics are defined as adaptations to configurations of game play as they occur during the game that can be thought of as strategic actions (Gréhaigne & Godbout, 1995). Gréhaigne *et al.* (1999) proposed that the strategic actions in team sports be divided into two types: tactics and schemas of play.

1. Tactics are decisions about how to move, when to move and where to move that are made in dynamic situations during a game. Tactical decision making must be practiced in open and dynamic game situations.

2. Schemas of play are pre-planned sets of actions, performed in a rehearsed manner (also called set plays). Set plays are practiced until they can be performed automatically.

In this study, both types of strategic thinking are considered to be tactics because success in both types of game situations involves the ability of a player to make the right decision at the right time in order to implement the correct action (Villepreux, 1993). Even during set plays, opponents will attempt to disrupt the pre-planned movements, which means that players will have to be prepared to adapt their actions spontaneously. Because of the continuous nature of game play in rugby, the end of a set play flows into open play, so a strict distinction between the predictable and unexpected situations is not always possible in rugby. This inclusive definition of tactics is compatible with the Gréhaigne and Godbout (1995) interpretation that tactics deal with:

- Changes in skills and skill combinations chosen in response to the perceived opportunities presented in specific game situations.

- Changes in positions taken in reaction to the movements on an opponent.

Tactical Decision Making

Tactics are the means by which the pre-planned game strategy is put into action. Tactical decision making is the ability of each player to perform appropriately in situations where the outcome is uncertain (Villepreux, 1993). Tactical decision making is the basis for each player's ability to adapt to changes in the game as well as to use his/her initiative to take advantage of opportunities in the game. Tactical decision making relies on each player's ability to assess his/her own strengths and weaknesses in relation to those of teammates and opposition, and then to take his/her actions accordingly (Gréhaigne *et al.*, 1999).

The specificity of tactics means that the tactical learning cannot be easily separated from technical skill learning, since a tactic is only successful if performed skillfully. Greenwood (2000) stated that it is important for players to understand the principles underlying strategic plans. These principles form the basis for tactical decision making. Practice sessions can be designed to help players learn to recognise the possibilities in a variety of game situations on the field. Players can practice in a variety of different situations in which the effectiveness of different attacks and counter attacks can be explored.

When players grasp strategic principles, it allows them to be more flexible in their performance of tactics in different situations (Greenwood, 2000). Some forms of attack are better in certain situations. During training situations, players and coaches can explore what works and what does not work. After the basics of these tactical situations are trained, players can practice making tactical decisions at speed and under the necessary defensive and offensive pressure. Players can also learn to associate certain tactics with certain visual signs that are cues to what is happening in the game situation.

Gréhaigne *et al.* (1999) emphasised that skill development must accompany the development of tactical decision making. This means that practice activities focused on the development of tactical decision making must also include attention to the technical aspects of skill performance. They noted that there is a difference in cognitive processing among strategies of tactical decision making that occurs during dynamic game situations and set plays (see Figure 4).

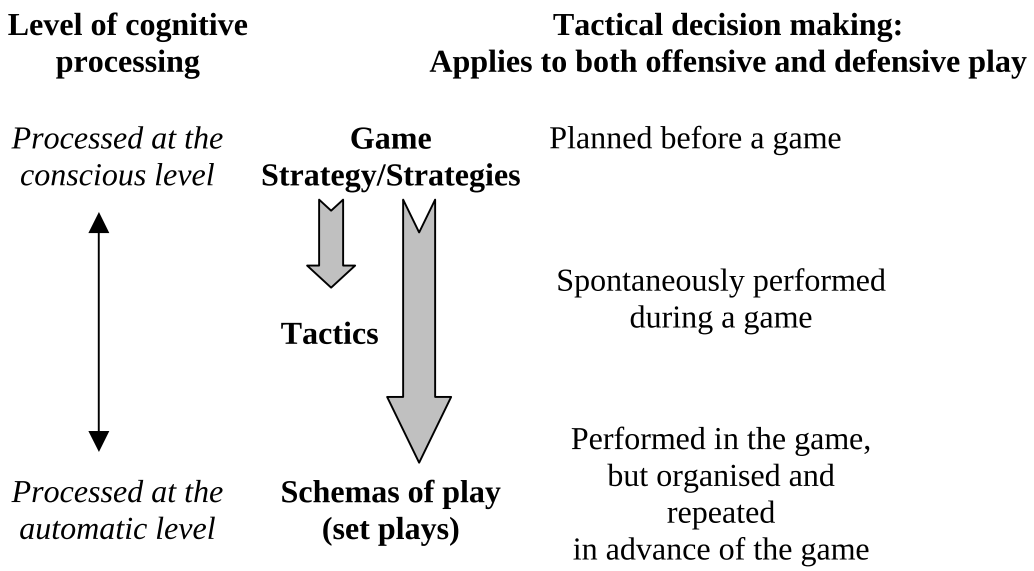

Figure 4

The relationship between cognitive processing and tactical decision making (Gréhaigne *et al.*, 1999, p. 168)

In the Gréhaigne *et al.* (1999) model, tactical thinking includes the continuum from conscious processing involved in the development of game strategies to automatic processing that characterises the performance of rehearsed schemas of play. Greenwood (2000) was convinced that teams that practiced tactical decision making would have the potential to control game play – that they would control the tempo of play and that they would make successful choices and actions at critical moments in the game.

Cognitive Processing and Decision Making

The process of decision making is the key to intelligent game play (Ross, 2001). Although decisions about strategies made before the game set the direction for decision making during the game, it is the quality of tactical decision making made by players during set plays and open game situations that determine the level of success in game performance.

Tactical decision making relies on cognitive processing (Magill, 2003), and has been defined as the product of perceptual and cognitive abilities (Abernethy, 1996). Different elements contribute to the ability to process information, including recall and recognition of sport-specific patterns of play, efficient visual strategies and the anticipation of future events. Cognitive processing includes the player's perception of what is happening in the game and his/her use of memory processes to draw on a knowledge base about the game to support the accuracy of those perceptions (see Figure 5). Cognitive processing is a collection of integrated operations that ultimately result in a decision about what actions to perform. The discussion of cognitive processing that follows is organised to present three components: Perception, knowledge, memory processes. These processes are highlighted in the information procession model used in this study.

Perception

Perception is a series of processes in which players gather information from the environment as well as from within their own bodies in order to understand the game situation. This information must be processed continuously so that players can constantly update their understanding of the performance context (Tenenbaum & Bar-Eli, 1993). Forming an appropriate and accurate perception of a movement situation is the first step in the successful performance of any form of physical activity. In terms of understanding the tactical challenges in highstrategy sport situations, the process of perception includes observation, visual search for cues in the environment, identification of relevant cues and an interpretation of what is possible in terms of tactical actions (Bressan, 2003).

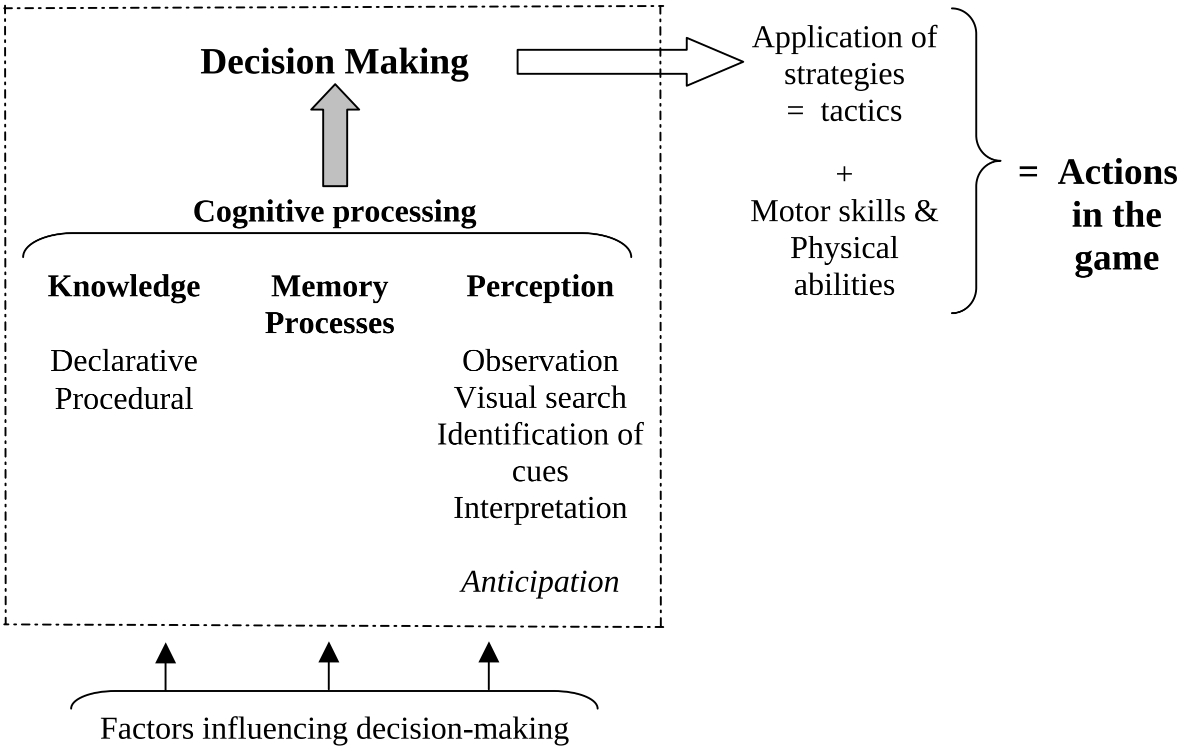

Figure 5

The relationship between decision making and cognitive processing components of perception, memory processes and knowledge

Observation

To gather information about what is happening on the field, players first observe the situation. Both the location of the player on the field and his/her posture and head position are critical factors in determining how much can be observed. Head and eye position in particular have an impact on the amount of information that a player can access (Gréhaigne, Godbout & Bouthier, 2001). From a strategic point of view, players try to position themselves so they can get the appropriate and accurate information about the performance situation, with special consideration for the position they play and their responsibilities within the team.

Visual Search

Decisions are made by players on the basis of what they perceive from the visual display (Smith, 1994). Visual search refers to the process of actively scanning the environment (Tenenbaum & Bar-Eli, 1993). For example, players scan to locate their teammates and opponents. They also scan to locate open spaces or spaces that may soon be open due to the movements of other players.

According to Tenenbaum and Bar-Eli (1993), visual search also relies on visual attention in order to gather visual information. Visual attention in sport is necessary in order to detect, recognise, recall and select stimuli when decisions need to be made. Players scan and then attend to the most appropriate stimuli. The quantity of stimuli affects the amount of time and effort required for an effective visual search. In a sport such as shooting, visual search is narrowed to the target. Controlling visual search in rugby means that a player can shift attention consciously in order to look for specific stimuli or “cues” that will be the key to understanding what is happening in the performance situation.

Visual search is accomplished through different eye movements (pursuits and saccades) and fixations (Ludeke & Ferreira, 2003). Peripheral awareness also provides critical information for decision making in sport. During a study completed by Ludeke and Ferreira (2003), visual skills were divided into software and hardware. Hardware includes non-task specific abilities such as ocular health, visual acuity, accommodation, fusion and depth perception (Ludeke & Ferreira, 2003). Software includes eye-hand coordination, eye-body coordination, central-peripheral awareness and reaction time. Software is as important as hardware in rugby. For example, the fly half and the scrumhalf need good central peripheral awareness, reaction time and visual concentration in order to play successfully. When the visual system is not working optimally, the player cannot perform to his/her full potential.

The importance of visual search in gathering information has contributed to an interest in visual skills training in rugby. Vaeyens, Lenoir, Williams and Philippaerts (2007) found that expert players spent more time fixating on the player in possession of the ball (the central point) than beginners, whose gaze alternated more frequently between that player and any other area of play. Tyler (n.d.) stated that there is growing interest among coaches in rugby training drills that include the development of visual skills such as peripheral vision, depth perception, dynamic visual acuity, concentration, eye tracking, visual memory, visual reaction time, focus flexibility and visual scanning skills. The ability of players to look up and scan the playing environment is not enough to support decision making. Players must also develop the ability to identify those pieces of information or "cues" in the environment that are critical indicators of what tactical decisions may be effective (Shaw, Gorely & Corban, 2005).

Identifying Cues

When looking for cues that will help a player read what is happening in the environment, the positioning of the opponents can be important. Are they changing their position on the field? Is the player getting ready to kick or making some space for an extra man? Does the fullback change position in the back line after the restart event? Of course, not all visual information is useful. Players must learn which pieces of visual information serve as "cues" for understanding what is happening. The players' attention should be directed not only at the position of the ball and the subsequent direction of the ball, but also at the positioning of the player and the adjustments he/she makes during performance.

Research by Tenenbaum and Bar Eli (1993) identified two different perceptual styles that may influence how easily players learn to use cues. The field independent style refers to the preference to attend to pre-selected details of information (cues) within the set of general information in a visual display, and it is susceptible to "tunnel vision." The field dependent style refers to the preference to remain open to look for cues in the entire visual display and it is susceptible to distractions in the environment. The perceptual style of field independence can be an advantage in team sports because the environment is loaded with pieces of information that are not relevant cues for making tactical decisions (Tenenbaum & Bar-Eli, 1993). Field independent players are more likely to be able to identify the relevant cues in open environments.

Interpretation

Michalopoulou, Papadimitriou, Lignos, Taxildaris and Antoniou (2005) noted that successful skill performance in volleyball relied on using the optical information players gather and interpreting visual perception. Interpretation is the link between gathering information and making a decision. It has been described as "forming a perception" and is categorised into two types (Bressan, 2003):

1. The recognition of a familiar situation based on past experiences in similar situations, stored in the memory.

2. The interpretation of new or unusual situations, which rely on the ability to make inferences.

Both the recognition and interpretation of information rely heavily on cognitive processing. Expert players demonstrate the ability to pick up the relevant information, use their knowledge structure for elaboration of these cues and select the appropriate response (Starkes & Ericsson, 2003).

Anticipation

A player who reads the game well is one who can anticipate correctly (Greenwood, 2000). He/she not only perceives what is happening, but can predict what will probably happen next, based on that perception. From the perspective of tactical decision making, anticipation is critical because it supports the prediction of the moves of teammates as well as opponents. This should improve the effectiveness of the actions performed as a result of the decision.

If a player can identify patterns in a game, anticipation becomes easier (Shaw *et al.*, 2005). Experience guides the sensory system to attend to certain cues. Knowledge structures are quickly accessed to interpret those cues and facilitate predictions. It is the experts' ability to anticipate which allows them to react faster. In an open-skill environment the player often needs to pay attention to several cues at the same time. One approach to assessing anticipation is to create a video-based test where participants are watching a sport situation and the videotape will be stopped before the completion of the situation. The participant is then asked to predict what will happen next.

Anticipation was studied in cricket batting (Penrose & Roach, 1995). It is known that batsmen try to learn to use cues from the bowler's actions to determine the location of each delivery so they can make the best shot. The researchers used video simulation of a batting situation where each subject had to predict the spatial location of 60 deliveries. Subjects were asked to perform what they thought was the appropriate shot after the display. The data were analysed to determine what cues were used by the subjects and at what point during the delivery action the most important cues were presented. The results indicated that the prediction of delivery location by the expert batsmen was more accurate than the predictions of any other group. Because correct prediction of the length of the approaching delivery has a direct effect on the decision of what type of shot to play, the researchers concluded that learning to anticipate line and length of delivery was essential for top level batsmen.

In a sport such as netball, anticipation has also been identified as a critical ability. Results from an Australian study (Bruce, Farrow & Young, 2004) demonstrated that highly skilled players make significantly faster decisions than less skilled players. The authors concluded that the highly-skilled players were better able to read the game than less skilled players. Highly-skilled players reacted towards the situation even before the ball left the player's hand.

Hughes and Wells (2002) studied the performances of penalty takers and goalkeepers in penalty shoot-outs in elite level field hockey. They found that there were definite cues that goalkeepers used to anticipate the direction of a shot by the penalty taker. Anticipation allowed the goalkeeper a split-second to reposition himself/herself.

Memory Processes

Ripoll and Benguigui (1999) used the term "intelligence" to describe the ability of expert soccer players to solve tactical problems on the field, a process attributed to retrieving knowledge from the long-term memory, comparing the content of incoming perceptions to the stored information, and then selecting the optimal actions based on past experience stored in the memory.

The link between memory process and pattern recall in chess was established by Eisele (2004), who found that all grandmasters had the ability to sum up a board in one quick glance. He concluded that the grandmasters could "chunk" the positions of the pieces on the board into fewer, larger chunks of information that could be more easily remembered and subsequently recalled to produce the required pattern. He also reported similar findings for team sports. Players developed the ability to recognise and memorise patterns of play. Members of the Australian netball team viewed a ten-second portion of a game and then were asked to recall the offensive and defensive positions of each of the players by plotting them on a diagram of a netball court. The highly-skilled players were correct for 72% of the positions while the least experienced groups were correct only for 57% of the positions (Farrow, 2007).

High strategy sport performers take years of preparation to develop the problem representations and specialised memory adaptations needed for decision making at top level performance (McPherson, 1999). These memory adaptations can be divided into event profiles that include the past and action plan profiles that include the general rules for choosing responses. Both profiles are stored in long-term memory and are ready for activation and for updating when new experiences are encountered.

Knowledge

According to Turner and Martinek (1999), both skill and knowledge contribute to game performance at all levels. Decision making in sport is based on knowledge. They described game play as a skill performance interwoven with decision-making opportunities. They defined each game situation as posing a problem to be solved. The ability to select appropriate responses in game situations is a type of decision making that requires several kinds of knowledge, including knowledge about the game and its goal and knowledge of actions within the context of game situations. “High-knowledge” individuals tend to process input information relevant to the goal structure of the game and to selectively process information related to the goal structure. An individual who is more knowledgeable about the sport is better able to select the appropriate response for a situation within the context of a game’s goal structure. McPherson & French (1991) specified that two kinds of knowledge have been found to be critical for decision making in sport: Declarative knowledge and procedural knowledge.

Declarative Knowledge

Declarative knowledge is stored in the “cognitive memory” since it consists of facts and concepts that can be expressed in words (Bressan, 2003). Declarative knowledge is an understanding of facts as well as generalisations (concepts) formed from past experiences. Long-term memory for declarative knowledge can be represented as a kind of hierarchy called a cognitive knowledge structure. The more knowledge about something, the larger and more detailed the cognitive structure that will be stored in long-term memory. Turner and Martinek (1995) were convinced that a foundation of declarative knowledge is necessary for the development of procedural knowledge, therefore adequate declarative knowledge base must be formed before one can develop good decision-making skills.

Procedural Knowledge

It can be described as knowledge about how and when to perform activities (Hadfield, n.d.). Declarative knowledge by itself will not allow the performer to take action (Paull & Glencross, 1997). Tenenbaum and Bar-Eli (1993) used the term “game intelligence” as the ability to learn and improve motor skills, to understand the game, to make accurate and fast decisions, to absorb knowledge, to know the strategies and tactics, to adapt quickly to continuously changing situations, and to have the correct timing, space and motor coordination. This combination of abilities represents the interaction between declarative knowledge and procedural knowledge. Papanikolaou (2000) preferred the term “athletic intelligence” to describe the same collection of abilities. With team sports, this kind of intelligence includes the ability to react quickly to the opponent’s style of play, to understand the basic principles of attack and defense and to successfully respond to every new situation on court.

Factors Influencing Decision Making

Both cognitive processing and tactical decision making are influenced by a variety of factors which have been highlighted by the box drawn on the model in Figure 6. For example, decision-making ability can also be influenced by the different cognitive components, such as concentration, attention, style, cognitive style, general intelligence, short-term memory, and anticipation. However, it is clear from the literature that the most critical variable that ties together these various factors is the player’s level of expertise (Ross, 2001). Expertise in sport reflects many years of focused and dedicated practice (Mulligan, Dobson & McCracken, 2005). Ericsson reported that expert musicians need about 10 000 hours of practice, previous studies found that expert sport players only had about 4000 hours on average, sport-specific training (Starkes & Ericsson, 2003).

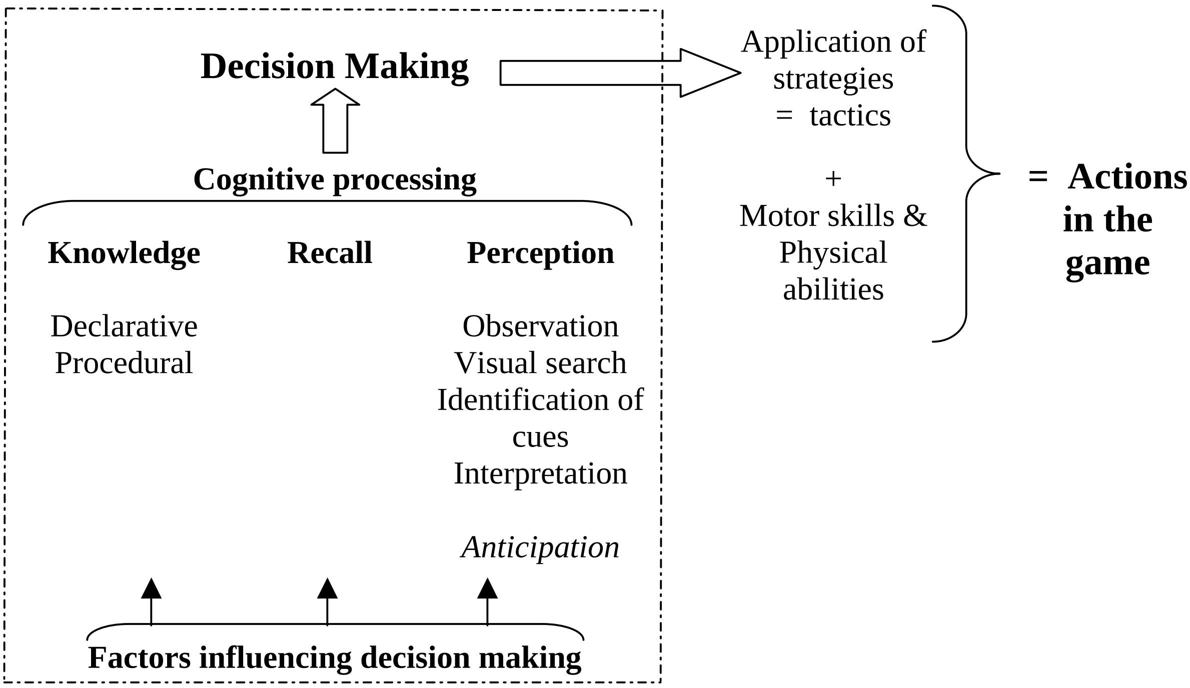

Figure 6

A variety of factors influence decision making

Expertise and Memory

According to Abernethy, Neal, Engstrom and Koning (1993) a unique combination of decision-making skills, visual aiming skills and force control skills is necessary to perform well in billiards and snooker. Each shot requires a mental and a physical approach. One of the aims of their study was to compare the performance of expert, intermediate and novice players. In their research of expert-novice differences, they included a test of pattern recall to determine the respective memory capabilities of the expert, intermediate and novice players. The subjects were shown slides that depicted the arrangement of balls on the table under different conditions for a period of five seconds per slide. The subject's task was to record the position of each ball on the table for each slide. These scores indicated that expert players could recall and pick up the game pattern more successfully. They also found that experts had better memory of patterns from previous game experiences. The researchers concluded that experts could plan ahead more effectively because they could anticipate patterns that would most likely occur in the game.

Most researchers have concentrated on the closed skill sport situations such as serving in tennis and putting in golf. In open skill situations, the ability to make use of advance information was found to be a discriminating characteristic between experienced and inexperienced soccer players (Williams, Davids, Burwitz & Williams, 1994). Experienced players have developed an extensive soccer-specific knowledge base that enables players to recognise meaningful associations between positions, movements and play patterns in game situations. This knowledge base provides good support for planning and decision making.

Expertise and Knowledge Base

Researchers suggest that decision making relies heavily on the amount and type of knowledge stored in the memory. When players are involved in a situation on the field they generate their responses from declarative and procedural knowledge, both of which theoretically increase with practice (Iglesias, Morene, Santos-Rosa, Cervelló & Del Villar, 2005). Years of practice are thought to be necessary in order to develop high-level skills and tactical problem solving ability (Ericcson, Krampe & Tesch-Roemer, 1993). Iglesias *et a*l. (2005) explored relationships among procedural knowledge, experience and performance in young basketball players. The procedural knowledge of 92 male basketball players was tested on a written test of tactical situations. Results showed that players with more years of playing basketball had a more extensive procedural knowledge base.

Hollier (2005) described becoming an expert in terms of changes in the way the brain handles information. During the early stages of mastering a problem solving task, brain activity is characterised by activity in the frontal area where conscious control of behaviour is processed. As players become competent, automation of some aspects of problem solving occurs. With repeated exposure to similar patterns and movements during game and practice situations, smaller bits of information about a task are associated together into bigger chunks of information. Instead of seeing individual moves, the expert sees a whole set of moves as a single cue. With still more experience, not only can the player interpret a set of moves, but he/she can accurately anticipate what the following moves are likely to be (Hollier, 2005).

Expert players were found to have more sophisticated game knowledge than players with less experience (Mendes & Tavares 2003). Their study focused on the theoretical knowledge of defense and players' ability to adapt defensive actions according to specific game situations. In order to analyse the level of declarative knowledge of defense, a written test with 18 multiple-choice questions was created, including technical and tactical domains and some game rules. Interestingly, although the more experienced players had better scores regarding rules in the defensive situations, there were no significant differences found between the more experienced and less experienced players on technical and tactical questions.

Differentiation between expert and novice players can also be identified through their more elaborate declarative knowledge base (Starkes & Ericsson, 2003). Expert players are able to access the necessary information through visual processing and can be more accurate with their perceptions based on that information than novices are. It is easier for them to access information from their more sophisticated knowledge structures.

Speed and Accuracy

According to Hadfield (n.d.), both speed and accuracy in decision making are influenced by the complexity of the performance situation. He defined complexity as the outcome of four aspects:

1. The numbers of decisions that need to be made;
2. The number of responses from which players can choose;
3. The amount of time available for making the decisions; and
4. The costs (penalty) associated with making the incorrect decision.

McMorris and Graydon (1997) looked at the effect of exercise on speed and accuracy of decision making among novice and expert male soccer players. The players' decision-making performance was tested under three different exercise intensities: at rest, cycling at 70% of maximal power output, and cycling at 100% of maximal power output. Soccer decision making problems were identified that were considered to be typical of attacking situations. Slides were made of these situations and were projected onto a screen for two seconds each. Participants were instructed to make a decision as accurately and as quickly as possible by stating whether the player in possession of the ball should run, pass, shoot or dribble. Overall speed of decision making and speed of accurate decision making were measured by voice reaction time. The answers were given into a microphone, which stopped the timer. The results showed that exercise had no effect on the accuracy of decision making for either group, but as exercise intensity increased, the speed and accuracy scores of expert players were significantly better than the scores of novices.

The classic research on speed and decision making was completed in the early 1050's by Hick (1952) and Hyman (1953). The conclusions of their work, called the Hicks-Hyman Law, established that there is a linear increase in reaction time as the number of choices increases. This means that anticipation is necessary if decisions are to be made in complex situations in fast ball sports (Glencross & Cibich, 1977). Dillon, Crassini and Abernethy (1989) explained the effectiveness of anticipation when producing fast and accurate decisions in sport as a function of calculating probabilities. They proposed that players store likely responses to certain situations in a kind of hierarchy. When reading a situation, the more experienced player will unconsciously calculate the probabilities of possible outcomes. If the player thinks there is a 70% probability of a particular outcome, he/she will pre-programme the appropriate response to that outcome. Pre-programming shortens the amount of time needed to initiate the response, which gives the experienced player more time than the novice to "keep reading" the situation and make a better choice.

Expertise, Visual Search and Cues

In a study that examined the tennis skills and problem representations during singles competitions for three different age groups, McPherson (1999) found that experts better identified cues and responded to information than novices did. According to Rendell and Morgan (2005), expert field hockey players applied a more economical visual search strategy than novice players. They presented the same video footage of hockey players performing different shots to a group of goalkeepers and a group of forwards and backs. Their aim was to compare the two groups' anticipation and visual search behaviour. They found that visual search rate was highly variable among novices. Experts recognised patterns and set plays quicker, which allowed them more time for decision making.

Intervention Programmes
to Improve Decision Making

According Housner and French (1994), the critical challenge for all training programmes is the transfer from practice to game performance. Research in sport has mainly focused on the transfer of motor skills training to game execution. The following sections present suggestions for approaches to training that are proposed to improve tactical decision making, and in a few cases, research is reviewed in which the effect of interventions has been tested.

Training Decision Making

Decision-making training can be defined as an intervention programme designed to enhance players' ability to make effective decisions under conditions of physical, temporal and environmental stress (Vickers, Livingston, Umeris-Bohner & Holden, 1999). Among the cognitive skills needed to be trained, is the ability to anticipate, to attend to critical cues, to concentrate, to retrieve solutions and to solve problems.

The aim of the study completed by Vickers *et al.* (1999) was to determine whether behavioural training or decision training was more effective in preparing participants to deal with the unexpected, difficult and unusual conditions in cricket. Two groups of subjects were involved. In each group were novice, intermediate and advanced level batters. Group one received the behavioural form of instruction, which involved direct instruction and an expert coach who demonstrated the basics of batting using a part-whole approach. The decision-making group received instruction in the form of an expert video model using the whole approach. Both groups experienced variable practice and training over a seven-week period. The behavioural group received feedback from a coach who analysed their batting technique on video and identified cues to improve their hitting. The decision-making group received reduced and delayed feedback. Their batting was also recorded and analysed, frame by frame (compared to the performance of an expert video model), but they received limited assistance in identifying cues to help improve their performance. The results were:

- The novices in both groups improved their batting performance.
- Intermediate level performance improved significantly more than novice or advanced performance.
- Advanced performance in both groups improved similarly.

Previous research indicated that the behavioural approach of simple to complex skill and tactical instruction initially achieved high levels of effectiveness in game play, but proved to be less effective than decision-making training as game play became more sophisticated and complex (Vickers *et al.*, 1999). Behavioural training requires that complex skills and strategies be broken down into sub-skills. High rates of repetition during drills in simple to complex progressions are the key to automation of decision making. Behavioural training is more effective in preparing novices. Decision-making training is more effective in preparing intermediate performers. At the advanced level, it is possible that different performers have developed their own preferences for training situations.

Mascarenhas, Collins and Mortimer (2005) looked at decision making in rugby referees. They observed that the accuracy of rule applications by referees is based on his/her knowledge. The aim of the study was to measure decision-making accuracy, agreement and coherence of decisions between England's best Rugby Football Union (RFU) referees, coaches and touch judges. Different scenarios of the tackle were recorded on video clips. The clip started five seconds prior to the tackle situation, running up to the tackle "incident" at which time the screen went black and the referee had to make a decision. Two full-time referees of the RFU pre-determined the correct response. Each subject's performances was measured by their scores on the clips, including accuracy of the decision, the agreement of the different referees and the coherence of the reasons they provided for their decision. Results showed that experts were not more accurate in their decisions, they were just a lot more confident in their decisions. The authors recommended a training programme to develop the declarative knowledge of referees, with special attention to discussions regarding the reasons behind decisions could contribute to the improvement of decision making.

Video Simulation

Basketball players' decision-making skills were trained and tested on an interactive video simulation decision-making test, which utilised life-size video projections of game situations (Farrow, 2004). The players were asked to react as in an actual game situation where they had to make a decision to shoot, dribble or pass. The players were divided into three groups where each group was required to complete three computer-based decision-making training sessions each week for four weeks. The training sessions required players to watch patterns of play from international basketball games where they were told to assume the role of the player with the ball. At any stage the footage could be frozen at a critical moment during the game, at which time the player had to decide what to do. The speed and accuracy of their responses were recorded. This type of training was proposed to improve a player's decision making on court during the game. The players reported that the training exposed them to effective decision-making training. Their scores on the post-test indicated an improvement in decision-making speed and accuracy.

Other studies have been completed dealing with training perception and cognition in sport through video simulation but the difficulties arise when the trained processes are assessed by on-field transfer tasks. Starkes and Lindley (1994) discussed a research project in which video simulations were used to try to improve the decision making of basketball players. Players of similar abilities were divided into three groups. The first group was trained to solve game problems presented to them in slides. For the second group, the game problems were presented in video format. The third group was the control group. The pre- and post-tests of decision making were video based. The test consisted of the presentation of critical points during the game. Subjects were seated 5m from the screen on which the game situation was projected. The screen was solid green. Three seconds after a subject indicated readiness, the video clip began. At a critical point in the game, the screen went black and subjects were asked to answer as quickly as possible what the next move should be for the offensive player with the ball: Should he shoot, dribble or pass? An attempt was also made to assess the on-court decision-making speed and accuracy of the players in the three groups. An on-court transfer test was designed where tactical situations were set up on a court and subjects had to decide what to do as quickly as possible. The two intervention groups received six 30-minute decision-making training sessions. The results of the post-tests revealed that subjects receiving the intervention programmed achieved a marked decrease in speed of decision making when compared to subjects who received no training. However, neither the slide nor the video training had an impact on the accuracy of on-court decision making. The researchers concluded that simulations can contribute to training decision making, but it is unclear how to measure the transfer of learning to actual game play.

A study completed by Burroughs (1984) evaluated the effectiveness of visual simulation training on improving the visual path recognition and pitch location skills of baseball players. Batting in baseball is a very difficult perceptual motor task. The batter must visually pick up the path of the pitch, recognise any spin on the ball, anticipate when the ball will be in the hitting zone, and then move his/her body to cause the bat to contact the ball. During the pre-test, film clips were created to represent a series of pitches. Each subject (N = 59) was asked to identify the type of pitch and anticipated location of the pitch when it entered the hitting area (each subject earned a recognition score and a location score for each pitch). The intervention programme consisted of practice reading pitch type and location was presented through video simulation training. Post-test results indicated that visual simulation training significantly improved the batters' ability to accurately determine pitch location. The author concluded that the use of video simulation training films for batters seemed to be a promising training technique.

There has been research to suggest that decision-making skill and anticipation can benefit from the increased use of video recording as a training tool (Scott, Scott & Howe, 1998). Tennis video recordings of serving actions have been found to be of help in developing more tactical returns of serve, especially for non-experts. However, this kind of off-court training is not seen as a replacement for on-court training, but rather as a complementary approach that can accelerate learning.

Video Games and Virtual Reality

Research has been done on the impact of playing video games on decision making. Mulligan *et al*. (2005) thought that video game play technology could be used to help players to practice decision making in sport. They noted that video games called for players to develop cueing strategies, pattern recognition and visual search strategies, all of which are needed for decision making. While much more research must be completed in this area, they did note that the ability to quickly and accurately make decisions was an important difference between experts and novices.

Virtual reality is used by football players to improve the performance of players. The CAVE (Cave Automatic Virtual Environment) is one system that is used as a virtual American football trainer (University of Michigan, 2004). The objective is to train a player for the correct visual perception of play situation and for the fast reaction to team movements of other players on either team. Players can go through countless repetitions of their own team's plays and learn the hundreds of formations and variations to offensive and defensive schemes. Coaches can use the virtual trainer as a tool during off-season to train the players. The virtual football trainer is proposed to assist players to develop the correct estimation of distances, the awareness of the location of players on either team, the recognition of individual players and the visual communication with the coach on the side line. Although no experimental evidence has been presented to document the effectiveness of this kind of training, virtual reality is an interesting concept that is worth exploring.

Vision Training

Some researchers have claimed that visual training can be the determining factor between winning and losing (Ludeke & Ferreira, 2003). Differences have been found between experts and novices on sport-specific pattern recognition and anticipation. Ludeke & Ferreira (2003) identified five visual skills for comparing professional to non-professional rugby players: eye-hand coordination, eye-body coordination, peripheral awareness, visual reaction time and visual concentration. Ninety-five (95) rugby players participated in this study. Although the professional players performed much better than the novice group, the authors concluded that there was room for improvement and they recommended that vision enhancement programmes be implemented for both groups. Another study compared the visual skills of ruby players from two different age groups (Venter & Ferreira, 2004). The older group outperformed the younger group on tests of the different visual skills. The authors speculated that the difference could have been due to a more advanced level of motor development or to more experience and coaching.

Leviton (1992) took the position that players and athletes need to exercise their eyes. He submitted that players can use eye exercises to enhance the ability of their eyes to relax, focus, shift, and work as a team, as well as to visualise. He stated that relaxation exercises are necessary to enhance blood circulation. Focusing exercises are necessary to strengthen the eyes' ability to quickly move from a near to a far point and then back again. Eye shifting exercises can discourage staring and help the eye to quickly move focus point from one visual field to another. Fusion exercises help to strengthen the ability of both eyes to work together in the same direction. Visualisation develops memory, which leads to better recognition of objects and situations.

Leviton (1992) described a variety of possible visual skill training activities. He included activities such as bouncing on a trampoline while performing eye exercises. He suggested this would help the individual to learn to perform visually while at the same time improving general body coordination and improving the ability to pay attention. The inclusion of challenges to balance in sport vision training exercises was recommended because of the importance of postural control in sport. He was convinced that players should become aware of how movement, posture and alignment of their body can affect vision. Posture is the basis for head position. The more optimal the head position, the better view the eyes will have of the critical visual field.

Research by Ripoll, Kerlirzin, Stein and Reine (1995) examined information processing, decision making and visual search activity of boxers of various levels of expertise using simulated video-based problem-solving situations. Subjects were placed in front of a screen where they had the image of a boxer in front of them. The subject had a joystick in his hand and had to respond to the opponent's offensive actions by manipulating the joystick. During the first experiment, response accuracy and reaction time of the subjects were analysed. The expert boxer's responses were more accurate but the reaction times were approximately the same for all groups. During the second experiment the visual behaviour of the subjects was recorded by using an Eye Movement Recorder. The results for the expert group showed that their scan paths closely followed the presentation of important visual cues by the boxer on the screen, and that their visual search path was in the form of the circle. In the intermediate group the scan paths were also closely related to the presentation of visual cues, but this was not the case with the novices. The authors concluded that if training programmes are to help novices improve, they must include specific activities to help novices learn to identify cues and to control their visual search to attend to those cues in complex situations and when under pressure.

Success in meeting the challenges of a changing situation during game play relies on how well the player can integrate and interpret information and then develop and implement a plan for action (Knudson & Kluka, 1997). One important aspect of this process is the efficiency with which players use their eyes. Knudson and Kluka (1997) recommend vision training as one way in which the coach can help players learn to focus on certain visual cues. Different colour balls or markings on equipment can be valuable to draw a player's attention and focus to certain visual cues. Visual training exercises can be incorporated in training or even during the warm-up of the session. During these exercises, the different eye movements used during a particular sport can be practiced specifically. This special attention to visual skills development helps to coordinate different eye movements needed to get information from the environment. In fast-action sports, players must practice following fast-moving objects and move their body in response to the pressure of time and speed constraints.

Training Tactical Understanding on the Field

Greenwood (2000) suggested that coaches build an understanding of space into the team strategy and tactics. For example, practices need to be designed so that players discover how much space they need for different attacking moves. The attacking team can play the ball wide or they can create space for themselves by using unorthodox formations in the backline. The aim is to get the defending team to commit themselves to a movement and then use another attacking move to focus on their weakness. Advantage can also be gained by kicking the ball into the space. This is also the easiest way to get over the gain line. During practice, the coach and players need to analyse the use of space during different tactical points in the game and discuss optimal solutions. Mendes and Tavares (2003) insisted that the preparation of young basketball players include knowledge of defensive tactics and techniques. It was their position that players need to know what to do (declarative knowlededge), make the correct decision about taking action, then have the time to execute that action (their technical skill).

It is important to create optimal conditions for learning tactical decision making. According to Gréhaigne and Godbout (1995), a player draws up a temporary mental representation that is his/her interpretation of reality and this becomes the reference for making decisions. When a player is unsuccessful during practice or game play, the player experiences a conflict within his/her explanatory system and experiences the need to construct a new representation that holds more accurate explanatory power. It is at this point that the coach has a "teachable moment." Stopping play to discuss options, cues, interpretations, etc., is a recommended coaching strategy for expanding procedural and/or declarative knowledge of the game.

Training sessions present practical opportunities to develop skill, in order for players to learn the limits within which they can operate. According to Villepreux (1993), players first need to concentrate on where the best position is on the field and then how to keep that position. When the opposition is introduced to a situation, different aspects of the game play come into consideration, including the speed of the situation, use of space, and how players can support each other. Each player has to pay directed attention to critical cues that provide insight into what is happening. If players do not actively search for cues, they will not gather critical information for decision making. The coach needs to help players find those cues and then act accordingly.

The Challenge to Decision Making in Rugby

During any game each player is required to read what is happening with teammates and the opposition as well as simultaneously recognise any tactical problems to be solved that arise from the interaction (Villepreux, 1993). Players have an advantage if they can anticipate what is going to happen next and are able to perform an appropriate action as quickly as possible. For the more closed situations, decision making is practiced in set plays with few options. The more open situations, mini-games and drills with multiple variations expose players to different tactical scenarios. These two kinds of practice activities should help players improve problem-solving skills and as well as their ability to act quickly on their decisions (Smith, n.d.).

Building a Knowledge Base

Thomas (1994) advocated the development of both declarative and procedural knowledge as part of the improvement of decision making. She noted that coaches and teachers can do the following to enhance knowledge development:

- Teach rules.
- Identify cues to help players to better understand skills and tactics.
- Explain strategies and how they should work (tactical examples from real game situation).
- Discuss and practice as many different options as possible.

- Reward and encourage players who select the correct options, even when they do not work.

- Watch other teams and players and discuss their performance.

Verbalisation is an approach to expanding the declarative knowledge base. It is possible to teach analytical decision making by talking about the situation, explaining what the best option is going to be and the reasoning behind the optimal decision (Hadfield, n.d.). The idea of conducting debates to encourage critical thinking followed by discussions about tactical options is recommended. Gréhaigne *et al.* (2001) identified verbalisation as evidence of cognitive processes. Their research found that verbalisation is a key process in the development of self-regulated behaviour, and it should enhance the player's construction of tactical knowledge and the development of decision-making skills.

The Use of Sport Technology

Game films have been found to be of great to use for player development because they can help players to learn to recognise patterns of play (Abernethy *et al*., 1993). Information from viewing films can help players with the basics of the game, for example, learning when to perform a certain action in what situation. It can also assist players to learn to analyse how successful their game decisions were and to identify certain strengths and weaknesses in themselves and in their opponents. The adaptation of what is seen on the film to what happens on the field is proposed to be possible.

A rugby match is a complicated collection of situations in which the movements made by players off the ball can be just as important as the movements made by players with the ball (Launder, 2003). Game performance includes decisions about support, defending space, covering teammates and adjusting positions as the game develops. Organising the complexity of offensive and defensive interaction in order to examine it, discuss it, and practice meaningful tactical options in response to it, has been simplified tremendously by the development of the computer-based sport technology, known as performance analysis.

Performance analysis is described as a combination of two sport science disciplines, namely, game analysis (notational analysis) and biomechanics (Hughes & Bartlett, 2002). Game analysis involves the recording and subsequent organisation of the various patterns of play that occur during game performance. It is primarily concerned with descriptions of the use of strategy and tactics. Biomechanical analysis is focused on the kinematic analysis of body movement. It is primarily concerned with individual skill techniques and effective skill performance. In rugby, for example, game analysis categorises the different set plays from a re-start event such as the scrum or the lineout, while biomechanical analysis reveals the mechanics of a player's kick in terms of technique and preparation for the kick, etc. Because this study is focused on decision making, only performance analysis in the form of game analysis will be discussed as a possible intervention strategy.

The primary purpose of performance analysis in a coaching context is to provide information about a sports performance to assist coach and player to make better decisions (Wilson, 2002). Using video material to illustrate game analysis has been shown to be an effective way for players to learn. Edited video presentations can be instructional as well as motivational. The coach can show the players both the positive and negative events in their games. Video material can be used to indicate areas for improvement, to pin-point certain techniques, to analyse the opposition, to show individual player strengths and weaknesses, etc.

Wilson (2002) was convinced that if coaches learned how to use performance analysis with their players, the following benefits would result:

- "More highly trained observation and perceptual skills
- Better decision-making skills and less assumption making
- Screening of information skills
- Anticipation skills
- Statistical awareness
- More refined feedback and communication skills." (p. 9)

Game Analysis

Game analysis is a technique used to analyse different aspects of game performance, which includes the analysis of movement patterns with special focus on tactical evaluation and statistical compilation (Wilson, 2002). A variety of software is used in different team and individual sports (Drawer, 2002). Software makes it possible for the video information to be tagged during the game when a notable event occurs. All these events are collected in a database. Categories of events can be created in order to retrieve collections of events for review. Real time analysis as well post-game analysis and presentation to players and coaches are possible. These data can be organised to expose the strengths and weaknesses of individual players and teams, which can provide a focus for the next training session or future games. The coaches' and players' interpretations of the information collected are central to the effective use of performance analysis (Lyons, 2002). The objective data provided by the software can be used in a variety of ways. The power of any game analysis system lies in the information provided. Once the video has been tagged or coded, captured and stored, all events can be cross-referenced.

Recorded games can be edited and selected clips can be presented to players the day after a game (Lyons, 2002). Recommend time for post-game analysis is limited to 20 minutes. For coaching sessions, it has been suggested that game clips can have an impact on learning if they are repeated three times. If a laptop is available, players and coaches can use the information during discussion groups or even while traveling on a bus, plane, etc. The information on the clips can also be used for imagery and visualisation. Players can pause a video clip and visualise each play for two minutes. Players can also try to visualise themselves performing, hearing the sounds, picking up the smells, and most importantly, feeling the performance in their muscles.

Although many coaches are able to anticipate events and make appropriate tactical changes to influence performance, even the best are prone to human error, leading to less than optimal decisions (Franks & Miller, 1991). Technological advances and declining costs have given coaches access to laptop computers, digital cameras and performance analysis software. Performance analysis can be used to generate game statistics and to identify critical aspects of play, called performance indicators. Game analysis was used to analyse penalty corners in elite level hockey (Laird & Sutherland, 2003). Penalty corners are extremely important and have a significant influence on the outcome of the game. The penalty corner is a set play that can be analysed in depth to determine what decisions were made. They analysed 250 penalty corners during the 1998 Field Hockey World Cup. Hockey on this level is played at a very fast pace where tactical decisions are extremely challenging because players need to act quickly and with confidence. Their results indicated that most goals were scored from straight shots that were either flicked or undercut - these shots were coming so fast that the defenders had little time to try to block them. Penalty corners, in the cases where a dummy was used, were less effective than straight shots. Players and coaches can utilise this information to try and eliminate unsuccessful choices, which proved to be ineffective for goal scoring.

Game Analysis and Statistics

Scientific recording of data in rugby started during the late 1970's when coaches started using game statistics to provide them with information about game performance (Franks & Miller, 1991). One of the first areas of focus was on tackle count as an indicator of a player's work rate. Subsequent interest was shown in scrum and penalty counts for each team, as television coverage generated interest by spectators in knowing more about what was happening on the field.

Film records and game statistics have become increasingly important as coaches realise that they cannot accurately recall all the situations they observe during game play. Research by Franks and Miller (1991) found that a group of international soccer coaches could only recollect 30% of the key performance factors after a game. Their research also showed that coaches can be trained to improve their memory for performance factors, but the percentage was still below 50% of what was initially seen during the game.

One function of game statistics is to give coaches a full picture of the rate or frequency with which their teams are successful. For example, if a coach discovers a team is loosing the ball at a high frequency when they go on attack, the coach knows that practice sessions must focus on how to set up attack, how to create and utilise goal opportunities and how to shoot a goal effectively (Winkler, 2001). Game statistics provide players with important feedback. If video sequences can be incorporated into the presentation of game statistics, players can also participate in analysing their tactical performance in relation with what they have learned in theory (Winkler, 2001). This should help develop an understanding of the game.

The effective use of game statistics was demonstrated in a study by Ibanez, Sampaio, Saenz-Lopez, Gimenez and Janeira (2003). They found that the most successful teams at a basketball championship tournament were those teams that had less ball possession per match but were more efficient when they had the ball. They were able to identify key indicators that discriminated between the teams that won and the teams that lost close games. Those key indicators were defensive rebounds, successful two-point shots and successful free throws. These three key statistics were the only statistics that discriminated between winning and losing teams in the very close games in that tournament.

The main aim of a study by Sampaio and Janeira (2003) was to identify basketball game statistics that best discriminated between winning and losing teams. Results indicated that losing teams performed poorly according to all game statistics. During close games, statistics indicated that field goals, free throws, fouls and rebounds were the most powerful game statistics discriminating between winning and losing teams. When winning at home, teams were characterised by committing fewer errors overall when compared to the losers. When winning away games, winners were characterised by fewer 3-point field-goals missed, more free-throws made and more defensive rebounds.

A study by Bazanov, Haljand and Võhandu (2005) used a game analysis system to examine the offensive teamwork of basketball players. One performance indicator that determined the outcome of the game was the defensive rebound, which puts a team immediately on offense and lead to an increase in the frequency of fast break events. The results showed that the fast break was a critical offensive strategy used successfully by winning teams.

Analysing the duration of ball possession in relation to success in soccer was the focus of a study by Jones, James and Mellalieu (2004). In order to score a goal a team needs to have ball possession, but should it be assumed that winning teams have ball possessions for a larger proportion of the game? It was found during a previous study that successful teams had longer periods of ball possession than unsuccessful teams (*i.e.*, when they had the ball, they kept if for a longer period of time), although no significant differences were found in the number of passes used in attacks leading to the scoring of goals. The results of this study challenged these earlier results. All ball possessions less than three seconds were removed from the data analysed. Many goal scoring opportunities were created from possessions consisting of a small number of passes. A very interesting finding was made that teams generally had longer ball possession when they were in the losing position than when they were in the winning position.

A special interest in the different strategies and tactics of soccer led to a study by Taylor, Mellalieu and James (2005) in which individual players' tactical behaviours were assessed and compared to team strategy within a professional soccer team. Tactical behaviours were measured through a combination of technical and spatial indicators in relation to on-the-ball behaviours. The first objective of the study was to complete inter-positional comparisons to distinguish the technical demands of each playing position. An individual player's tactical actions can be related to position tactics and overall team strategy and therefore it is possible to determine how his/her tactical actions contribute to the team's strategic plan. The researchers used a combination of on-the-ball technical indicators and spatial information defined in terms of the field areas within which behaviours were exhibited. Individual analysis of the tactical behaviour of a player within a specific playing position was compared to other playing positions. The team strategy was evaluated by putting together the technical and spatial data with the communication from the coaching staff of the team. Through this approach, contradictions in the tactical actions of the forwards were found. Defensive play was characterised by frequent aerial challenges, clearances and tackles, and midfield play was dominated by crosses and dribbles.

Bar-Eli and Tractinsky (2000) used game analysis statistics to explore the psychological impact of time pressure experienced by players towards the end of basketball games. A basketball game can be structured into six psychologically meaningful phases namely a beginning, main and end phase within each half. Two dimensions were used: The criticality of game situations and the quality of the decision behaviour. Three experts were invited to watch the final five minutes of a basketball game. They were requested to identify all ball possessions included in the five minutes of play. They also were asked to indicate the degree of criticality of each possession. Situations during the end of the game were evaluated as highly critical. During the second stage of the study, the three experts evaluated team and player decision making behaviour in the critical situations. Results revealed that during the final phase of the game there were twice as many highly critical possessions than low-criticality possessions. Results also indicated that during highly critical possessions, a lower accuracy of decision making was evident among all players.

Game Analysis and Rugby

Game analysis has been used to evaluate and map different aspects of rugby, including the tactical aspects of the game, the physical demands of performance, the technical analysis of performance and additionally also to assess the effects of rule changes on game play and the consequences of rule changes to incidence of injury. Laird and Lorimer (2004) compared key statistics collected by the International Rugby Board in their review of the variables leading to the scoring of tries in the Rugby Union. The key variables identified were:

1. The position on the field of play when possession was obtained.
2. The number of passes preceding a successful try.
3. The number of second phases preceding a successful try.
4. The point in time a try is scored during the game.

The results of their investigation found that 75% of the tries came from possession gained within the opponents' half and that 39% of tries came from possession gained within the 22m line. They also reported other research where it was found that 50% of all goals came from possession gained within the opponents' third of the field of play. Most of the tries took place at the end of time periods, which they attributed to a combination of fatigue and failing of concentration. Coaches can use this information to make changes in training and tactical practice activities.

Game statistics are also valuable for detecting shifts in the strategies used by teams. Eaves, Hughes and Lamb (2005) analysed 24 games of the Five Nations and Six Nations Championships (1998 – 2002) using a hand notation system to collect data. They reported that there are significantly fewer line-outs and that teams tend to kick away ball possession more often than they did prior to recent changes in the rugby laws. They also indicated that there is more frequency of ball handling and maintenance of ball possession than previously evident in game play. Kicks in play have also increased. These results reflect changes in the tactical decisions facing players during the game, and should be reflected in practice sessions.

Prim, van Rooyen and Lambert (2006) determined that the South African Rugby teams participating in the 2005 and 2006 Super 12 competition "under-performed" if their performances are compared to the Tri-nation Rugby Competition for the same years. Possession retention in the tackle situation was identified as one of the areas in which the South African regional teams were less successful than their Australian counterparts. The tackle situation is constituted of four parts (Prim *et al*., 2006):

1. "Contact
2. Ball carrier going to ground
3. Support play
4. Availability of the ball after the tackle" (p. 127)

They described that the time taken by a team after a player goes to the ground with the ball is associated with attacking play. In top-class rugby, a fast attack is seen as making the ball available for play within three seconds. Fast attack is an advantage because the opposition team does not get enough time to re-organise themselves, therefore the attacking team has more space and options to attack. The study revealed that the New Zealand teams have a higher tempo of play and scored more tries than the South African teams.

Performance Indicators

The contribution of game analysis and statistics to improving tactical decision making may be in the identification of performance indicators. According Hughes & Bartlett (2002), a performance indicator is defined as a selection or combination of variables that define a moment of time in a game at which something "critical" can happen. Therefore, performance indicators have a direct relation to successful game performance.

A performance indicator in rugby is any point in the game where there is a pause in play that allows a team (or player in individual sports) to start a new attacking move, for example, kick offs, rucks and mauls, penalties, scrum and line-outs in rugby (Hughes & Bartlett, 2002). Performance indicators identified during game analysis are usually categorised as either scoring indicators (e.g., play leading to tries, drop goals and penalties) or indicators of the quality of performance (e.g., turnovers, tackles and passes). Both types of indicators measure positive and negative outcome of performance.

Accuracy in passing is a general technical indicator of overall success in most team sports (Hughes & Bartlett, 2002). Technical weaknesses may be revealed if one looks at the reasons for loss of ball possession. An examination of tactical decisions reveals the relative importance of teamwork, space, speed and movement. The data of previous and current performances can be compared with each other to determine if a team or player is improving in game performance.

Jones *et al*. (2004) were interested in putting together a valid and reliable method for the analysis of rugby performance indicators. Twenty-two performance indicators were listed by expert coaches and analysts after comparing the performances of winning and losing teams. This list led to the creation of performance profiles. Performance profiles are defined as the pattern of performance from a team or individual, which are created through frequency of the performance indicator during the analysis process. Their results confirmed previous findings that winning teams' forwards were more dominant in the line-outs, as well as in the driving areas of the game.

Performance indicators in sport are not necessarily stable properties because performances vary from match to match. Different factors can influence relevant performance indicators on any given day, ranging from the weather to the opposition. This is why it is recommended to generate data from multiple games and then determine the mean and standard deviation for each performance indicator. In this way, a calculation can be made of performance consistency over a collection of matches that can be considered an accurate performance profile. O'Donoghue (2005) defined the mean of a performance indicator as a descriptor of the typical performance for a subject or team, while the standard deviation represents the spread of performances around that typical performance.

The aim of the study by Boddington, Lambert and Waldeck (2003) was to determine whether a consistent performance profile could be identified for club-level women's field hockey. Consistency was defined as the minimum number of matches that could be analysed to form a consistent profile. Many of the game variables did not show any consistent performance profiles, even after 10 matches had been analysed. A comparison was made against the same opposition during a 2^{nd} game with a different match outcome. The authors found significant differences in two areas: the number of attacking short corners and the number of shots against. When a team was consistently dominating their opposition, the majority of the play took place within the attacking half of the field. This observation supports the conclusion that the quantity of ball possession has a strong impact on team success.

Conclusion

Rugby is a highly tactical and challenging game that presents many decision-making situations to the players in all positions. Abernethy (1996) stated that the practice of movement execution is important in sport, but more emphasis should be placed on the training of perception and decision making as they are more likely to be limiting factors on the achievement of success than are physical factors. Strategies and tactics form the content of decision making. Decision making relies on cognitive processing, a collection of integrated operations that ultimately result in a decision about what actions to perform. In order to play rugby at a top level, players must become good decision makers.

Helping players become fast and accurate in reading situations and making optimal decisions about what action to take, is one of the jobs of the coach. During any game situation, players need to become aware of the different options available which include observation of the situation, scanning for cues and interpreting their meaning. The process is made much easier when players learn to anticipate accurately because anticipation gives them more time to plan and execute actions. Many coaches are now turning to sport technology to assist them in keeping track of the strategic and tactical patterns followed by both their own teams as well as opponents. Analysis at this level is usually completed through the use of computer software that can process digital videos of game play and categorise the critical incidents in a game (the performance indicators) in order to easily see what happened tactically. Software has been developed to the point where the quality of decision making achieved by individual players can also be tagged during a game and played back later for analysis.

Efforts to improve cognitive processing in order to improve decision-making abilities of players can take many forms, including the use of game analysis, statistical analysis of game play and the discussion of tactics. Expanding the declarative (cognitive) knowledge base also has been proposed as a way to improve decision making. Grimison (2006) was convinced that tactical decision making could be improved through sport vision training. The remainder of this study is focused on a description of a research project that was implemented to determine the impact of a 16-week intervention programme on speed and accuracy of decision making, declarative knowledge and selected visual skills of u/20 rugby players.

Chapter Three

Methodology

The purpose of this study was to determine the effectiveness of an intervention programme to improve the following attributes of u/20 rugby players:

- Speed and accuracy of decision making;
- Declarative knowledge; and
- Visual skills.

The research method and procedures used in this study are described in the following sections.

Research Design

Because the intervention programme designed for this study was multi-dimensional and extended over several months, it was necessary to locate a full-time rugby academy that was willing to serve as the experimental group. It was accepted that the intervention would be highly applied and that the coach of the academy would be able to adapt the content as he felt necessary in order to prepare his academy team for competition.

A second full-time academy volunteered to take the pre- and post-tests in order to serve as a control group. It is, however, not accurate to refer to this group as a typical control group since it was not possible to ensure that the content of programmes in the two academies was identical with the exception of the intervention activities. It would be more accurate to call the second academy a “comparison group,” since the intervention activities were definitely not part of this academy’s programme. The term comparison group will be used throughout the remainder of this study. This means that two intact groups were used in this research. Because random assignment of subjects was not possible and the two groups were not the same size, this research is classified as a quasi-experimental nonequivalent control-group (comparison group) design (Thomas & Nelson, 2001). The question remains, how similar were the two groups?

- Players were the same age and drawn from the same pool of young players.
- Both academies are full-time residential rugby academies.
- Both academies played in the same league.
- Each academy had a similar framework for their practice schedules, with similar amounts of time devoted to skill development, fitness training and life-skills training as part of their weekly activities.
- Both coaches are professional coaches with over 15 years coaching experience at this level.

Procedures

The following procedures were followed in the development and implementation of this research.

Identification of Assessment Instruments

Three measurement instruments were used in this study. Because no standardised instrument was available to assess speed and accuracy of decision making or tactical knowledge, two original tests had to be developed. Visual skills were assessed, using the Sports Vision Assessment battery of tests and norms developed by the Stellenbosch University.

The Test for Speed and Accuracy of Decision Making

The challenge was to create a realistic test of speed and accuracy of decision making in rugby. The researcher decided that a computer-based test using video clips from actual rugby matches would provide the necessary challenge to players' tactical understanding and also allow a measurement of the speed and accuracy with which they made their decisions. Video recordings of four 2005 rugby u/20 league games were chosen by the researcher to serve as the material for creating the test. This is the same league in which the subjects in this study competed.

In order to make a decision about which situational clips would be suitable for testing decision making, an expert coach from the u/20 league was invited to watch the videotape recordings of these games. The purpose of the expert coach watching the games was to identify the variety of tactical situations that confront players during real game play. The expert coach was specifically asked to identify those clips that best/most clearly illustrate a recurring tactical situation in the u/20 competitions. The researcher was present at each session to stop the video as requested by the coach. The coach could ask to stop the video whenever he wanted in order to make a video clip of a situation in the game that he believed represented a tactical decision in rugby.

The videotape replay was connected to a laptop where each selected situation was immediately recorded as a video clip and saved when identified by the coach. When the clip was stored, visual material was cut just before the players in the clip "made a tactical decision." When the researcher stored the clip, the expert coach had to identify what the "best decision" would be in that situation. The researcher then wrote down the optimal answer for each situation. The same procedure was followed until all four games had been reviewed.

A total of twenty-eight suitable clips were identified. The clips and a record of the optimal answers were given to a computer programmer, who developed custom software. Most of the application was written in Microsoft Office Access. The final test package involved 28 scenes, each illustrating a tactical situation on the field. Every scene stopped when the player who possessed the ball was in a situation where he had to make a decision. This "freeze frame" of the rugby game situation was held for eight seconds. The participants were asked to make a tactical decision as quickly as possible, about the further development of the attack. The question was put to the player: "What action do you think should follow?" The participants could choose from responses that were in boxes at the bottom of the screen, just under the video window:

1. Run
2. Go to the ground
3. Pass
4. Kick

The participants had to make their decision as quickly as possible by moving the mouse and clicking their choice. The time between the freezing of the scene and the clicking of the mouse on a response box was recorded by the software and stored. The correctness of the response was recorded at the same time as the software compared the subject’s response to the optimal response of the expert coach that had been stored in the database.

After the decision making test was pilot tested by 10 players not taking part in the study, it was loaded and installed on the university’s network. This allowed the researcher to assess the speed and accuracy of decision making of 25 players at the same time in the university’s computer laboratory.

The test re-test reliability of this decision making test is presented in Appendix A. Thirty-eight subjects were randomly selected from groups 1 and 2 to complete a second administration of the test within 10 days after the post-test. The determination of reliability was based on the percentage of agreement of subjects when both administrations of the test were compared. An average agreement rate of 93% was achieved, which was considered acceptable as evidence of reliability. For the researcher’s own interest another expert coach completed the test and did not give exactly the same answers as the expert who put the different clips together. This discrepancy highlights the difficulty in assessing accuracy of decision making. Different coaches (and players) with different strategic approaches to the game may well make different choices in different problem situations. This reality was mentioned in the limitations stated in Chapter One of this study.

The Testing of Declarative Knowledge

A knowledge test is a commonly used instrument for assessing a player’s understanding of what to do in a given situation. Multiple-choice knowledge tests examine a player’s ability to sort through plausible answers and then identify the correct answer. The knowledge test selected for this research test consisted of 50 multiple-choice questions related to rugby situations and rules. The test is used by the South African Rugby Union (SARU) to test referees and players and is written as the SARU examination (validity and reliability established by SARU and assumed to apply to this group).

The Testing of Visual Skills

Vision testing was completed at the Department of Sport Scientist at the Stellenbosch University in the motor learning laboratory. An optometrist, Dr Ken West, had developed the test battery in 1994, included the test items and specific procedures for testing (see Appendix B). Four test administrators assisted with this study (intra-administrator reliability 0.89 to 0.94). The test protocol used was designed specifically to assess the visual skills proficiency of players of invasion games. Norms for interpretation of scores on each test item had been generated previously from ± 250 players of invasion games. The motor learning laboratory has a separate testing station for each of the following visual skills (definitions from Erickson, 2007):

1. Static Visual Acuity

   The ability to focus and see detail of various objects/people at any distance, while both the player and the object are still.

2. Dynamic Visual Acuity

   The ability to focus and clearly see detail of various objects/people at any distance, when the player, and/or the object/people are moving.

3. Peripheral Awareness (left and right)

   The ability of a player to pay attention to what he/she is looking at (maintaining central vision) while being aware of what is happening to the left and right side of the surrounding environment.

4. Pursuits (Smooth Saccades)

   The ability to "team up" the two eyes together to perform as a unit. When an object/person is moving slowly enough to allow the eye to maintain continuous focus. Pursuits are also called visual tracking.

5. Vertical Saccades

   When an object/person is moving too rapidly on a vertical path to maintain focus while tracking, the brain must estimate the path of the object and move quickly to intercept it and fixate on it for a split-second, then shift quickly to the next expected point of interception. The movement of the eye is called a saccade and there is no processing of information during the saccade itself. Processing only occurs briefly when the point of fixation is reached.

6. Horizontal Saccades

   When an object/person is moving too rapidly on a horizontal path to maintain focus. It is the quick movement of the eyes as described above for vertical saccades.

7. Near-far Saccades (Convergence/Divergence)

   Rapid shifting of focus from near to far and/or far to near is provided by near-far saccadic eye movement.

8. Coincident Timing

   The ability to anticipate where and when an object/person will arrive at a certain point in time and space.

9. Visual Memory/Concentration

   The ability to remember what has been seen.

The reliability of these tests (test re-test r .87) were previously established by studies completed in the Motor Learning Laboratory at Stellenbosch University.

Validity of the Assessment Instruments

Face validity is proposed for the speed and accuracy of decision making tests. It is a testing format that has been used in previous research. Tavares (1997) studied the effect of experience on the quality and speed of tactical decision making where players had to select the correct tactical response by pressing a key on the keyboard connected to the computer. An expert coach was used as the resource for both developing the tactical situations and identifying the preferred responses.

Face validity is also proposed for the knowledge test. It is a formal test that was generated by the South African Rugby Union's Board of Referees that is accepted as the resource for the application of rugby rules.

The validity of the sports vision test battery is based on its compatibility with other sport vision test protocols, such as those presented by Erikson (2007) as a measurement of the visual skills that contribute to sports performance.

Selection of Subjects

The directors of two different private rugby academies were approached and invited to participate in this study. These academies both included u/20 players who competed in the same league. Both had full-time residential programmes, suitable facilities and professional coaches. Both academies presented a full schedule of training activities each week (see Appendix C). One academy was particularly interested in being the experimental group and the other requested that they be the comparison group. Group One (experimental) consisted of 36 players. Group Two (comparison) consisted of 50 players.

The players in both groups were briefed about the purpose of the research at separate academy team meetings. The director of the experimental group adopted the intervention programme as part of the formal programme of his academy. The director of the comparison group academy was interested in the pre- to post-test changes in his players over the course of the season, so he adopted the tests in this research as a part of his normal testing programme. The inclusion of the pre- and post-tests as part of the performance assessment programmes of the academies and the inclusion of the intervention programme as an integral part of the formal programme of the experimental group academy, meant that this research was conducted under the signed informed consent forms completed by every individual player prior to his admission into the academy. Players did have the option of stopping their participation in any of the testing sessions, and players from the experimental group also had the option to withdraw from any of the intervention activities.

Pre-tests

Separate times for each of the academies to complete their pre-tests were scheduled during February and March of 2006. The same procedure was followed for the testing of each group.

Speed and Accuracy of Decision Making

A computer classroom at Stellenbosch University was set up for administration of the test for speed and accuracy of decision making. The classroom had a data projector and 25 individual computers, each with a headphone. When subjects sat down in front of their assigned computers, the researcher had already turned on the computer and the screen was ready for use. The researcher then gave a short introduction and explained the purpose of the test. The subjects were told that the first three of the total of 28 clips were practice clips. The group was then taken through the following steps with the first clip:

1. Please enter your name and surname in the correct order.
2. Complete the information area.
3. Please raise your hand if you do not understand or experience any problems or want to ask any questions.
4. In front of you, you will see the black screen for the video.
5. You will also see the four different colour icons/options.
6. On the left-hand side of the screen is a start icon.
7. In the middle of the screen is an icon that indicates the number of the clips to complete.
8. Press OK first.

10. Press Start.
11. The clip of the rugby situation will immediately start.

12. As the first situation is presented on the computer screen, a timer is activated. You see the action up to the point where the action is “frozen”. Watch and when the screen freezes you can immediately make your decision.

13. Make your decision by clicking with the mouse on the correct icon/option. This will cause the screen to go dark, and stop the timer.

14. You will have a maximum of eight seconds to make your decision, but answer as quickly as you can.

15. The time and accuracy of your decision will be measured.

Once all the subjects had responded to the first practice video clip, the group was taken together through the second and third practice clip. When the group indicated they were all ready to start the test, the researcher directed them to press OK and then start with the following test clip. The subjects could then self-regulate the initiation of the clips for the remaining 25 situations, although there was a maximum of eight seconds to respond to a situation before the computer programme automatically presented to the next situation.

When a subject finished, he waited at his computer until all the other subjects had completed the test. When everyone was finished, the subjects were thanked and dismissed from the classroom.

Declarative Knowledge

After completing the accuracy and speed of decision making test, subjects were taken to an open classroom at the university. The subjects only had to write their names and surnames on the first page and then could start completing the 50-multiple-choice test. The subjects were directed to mark the correct answer with a cross. Subjects had 40 minutes to complete the test. Most players completed the test in approximately 30 minutes. No player took the full 40 minutes allotted.

Visual Skills

The visual skills tests were administered as part of the physical performance test battery scheduled for each of the academies on different days in February 2006. During this testing period all players had an appointment with the doctor for a normal routine check-up. The testing session was 35 minutes in length for each player. Subjects reported in a group to the Motor Learning Laboratory. Following a brief introduction to the purpose of sports vision testing, the procedures for testing were explained. The score sheets were then distributed to the subjects.

Each visual skill was tested at a different station. Subjects were randomly assigned to an initial station for their first test and then rotated to each of the other stations in turn in order to complete the 10-item test battery. Trained sport scientists administered the tests and recorded each subject's score on the score sheet. A maximum of 20 players could be tested in the same time period. When a subject had completed all 10 tests, he returned his score sheet to the test administrator and then returned to the gymnasium.

Intervention Programme

The purpose of this experiment was to determine the impact of a multi-dimensional intervention programme on the speed and accuracy of decision making, the declarative knowledge, and the visual skills of u/20 rugby players. Table 1 presents a summary of the different kinds of intervention activities that were delivered to the experimental group. Five different kinds of activities were included in the intervention programme:

1. Statistical analysis of individual players
2. Game analysis
3. Tactical rugby discussions
4. Rugby rule discussions
5. On-field visual skills training activities

The experimental group also followed their normal rugby season routine, which included their rugby training and related fitness activities and matches. Both the experimental and the comparison group participated in 14 matches during the course of their season.

Table 1

Training activities in the intervention programme

Intervention Activity	Number of sessions
Statistical analysis of individual players	12 sessions @ 40 minutes each
Game analysis	14 sessions @ 40 minutes each
Tactical rugby discussions	5 sessions @ 40 minutes each
Rugby rule discussions	5 sessions @ 60 minutes each
Visual skills training	12 sessions @ 35 minutes each

Statistical Analysis of Individual Players

On the Monday morning, following each game on a Saturday, each subject in the experimental group was given the task to evaluate certain game events and also to evaluate the performance of a certain individual player during the game.

When assessing selected game events, each subject received a form to be taken as a guideline, with certain categories that he had to complete while watching the game. For example, each player had to analyse one restart event (e.g. line out, scrum, penalty) for a team. This was a paper and pencil task on which each player used a sketch of a rugby field to mark where on the field the selected event happened. Then, a conclusion had to be noted in which the player decided if the event was successful or unsuccessful, and if unsuccessful, what the difficulties were and which players were involved.

When assessing an individual player, a summary had to be made of the performance of that player during a selected event. Feedback to that player was provided to all teammates in a group session, specifically about the player and the game events, as if the subject was in the role of a coach.

Game Analysis

During the week after a game was played, an in-depth analysis and discussion of the decision making in the game were conducted by the academy coach with the team. Because the game was recorded and analysed using the Focus X2 analysis programme, it was possible for the coach to identify video clips as situations on the field to help focus his discussion. The coach of the academy not only focused on specific strengths and weaknesses of the academy but also had a look at the analysis of the opposition team. The academy used game analysis as a specific tool to improve game performance. The coach and the analyst did meet before each session on a Monday. The analyst showed the different clips to the coach. Each game was analysed in exactly the same way, with a specific category set (Appendix D). The coach told the analyst to put identified clips together for the intervention session with the players. Each session (one per week) followed a similar pattern. Several clips (± five) were presented and discussed in terms of what went wrong on attack and how to solve the problems, followed by a few clips (± five) on what was successful on attack and why. Then, the focus moved to the opposition team. Examples were also shown of certain set plays that were targeted for practice in upcoming practice sessions.

Tactical Rugby Discussions

The coach divided the 36 players into six groups while keeping the forward- and backline players together. The coach prepared in-depth sessions to conduct position-specific discussions for each group. Specific video clips from game analysis were used to illustrate the points that the coach was trying to make. The coach did ask questions and interactive discussions with players were encouraged. The aim was to provide each player with more position-specific knowledge. Each individual's game play from the previous match was evaluated in terms of strengths and weaknesses. The coach also shared with the group some examples of what he considered to be ideal performances.

Rugby Rule Discussions

A top international rugby referee was invited to the academy to discuss rugby rules and explain rule changes to the players. Each session was aimed at learning what is allowed and what is not allowed according to the rules, with an emphasis on taking a player's perspective. The sessions also entailed some detail about how and why different referees may see and interpret certain situations differently. Specific situations were discussed from previous matches and referee decisions were analysed.

Visual Skills Training

A total of 12 specifically designed visual skills training sessions were presented to the subjects in the experimental group in February, March and April. The sessions were 35 minutes in length. These sessions were integrated into the morning speed and agility training sessions.

Although the 10 visual skills, that were on the sports vision test battery, were incorporated into the sports visual skills training activities, most of the training activities involved eye-hand/coincident timing and peripheral vision activities. Visual skills training sessions were designed to be rugby-specific. As the group experienced success in an activity, the pressure to perform increased to create a kind of progression each day. A sample of a visual skills training session is presented in Appendix E & F. A record of the visual skills included in each session is presented in Appendix G.

Post-tests

The same procedures followed for the pre-tests were followed for the post-tests. The same test administrators were also available and they administered the post-tests. Vision post-testing for both groups took place during June, 2006, in the Motor Learning Laboratory. Both groups' accuracy and speed of decision making, as well as declarative knowledge was post-tested during September and first week of October, 2006.

Data Analysis

All data collected from all the different tests were entered in an Excel format and processed using the SPSS statistics programme and the appropriate *t*-tests for repeated measures, were completed to determine group differences (see Table 2). The significance level for all test variables was an alpha level of 0.05.

Table 2

Plans for Data analysis

Variable	Within Group	Between Groups
Speed of Decision Making	Dependent *t*-test	Independent *t*-test
Accuracy of Decision Making	Dependent *t*-test	Independent *t*-test
Declarative Knowledge	Dependent *t*-test	Independent *t*-test
Visual Skills	Dependent *t*-test	Independent *t*-test
	Frequency table and figures to identify improvement in various visual skills	

Summary

This study was designed and implemented to address three aspects of decision making in rugby. First, speed and accuracy of decision making was assessed. In this research, an original test of 25 video clips was created to identify any changes after an intervention programme. Second, the player's declarative knowledge was determined with a multiple-choice test. Changes in their knowledge after an intervention programme were determined. Third, visual skills were tested, using a standardised vision test battery. Changes in visual skills were determined after completion of an intervention programme. The participants' scores on each of these variables were processed to determine if there were any significant differences from pre- to post-test performance, and if there were any significant differences between the subjects who received the multi-dimensional intervention programme and the subjects in the comparison group.

Chapter Four

Results and Discussion

The results are presented in relation to the three research questions that guided this study. The primary purpose of this study was to explore the effectiveness of a comprehensive tactical understanding intervention programme on the speed and accuracy of decision making, declarative knowledge and visual skills of u/20 rugby players.

The scores of subjects from both the experimental group and the comparison group on the following three tests were analysed:

1. A 25-item video clip speed and accuracy of decision making test.

2. A written 50-multiple-choice question test (declarative knowledge).

3. A sports vision test battery (visual skills).

Dependent paired *t*-tests were used to determine pre- to post-test changes within groups and independent t-tests were used to determine differences between the experimental and comparison groups. When calculating between group differences, the scores of all subjects were used, regardless of whether they completed both the pre- and the post-tests. In addition to *t*-tests, a frequency table was created to report changes in visual skills.

Research Question One

1. Will the speed and accuracy of decision making of u/20 rugby players be improved following participation in a 16-week programme designed to develop tactical understanding?

This question is answered in two parts. First, changes in speed of decision making are presented. Second, changes in accuracy of decision making are presented. Because speed and accuracy are interrelated for successful decision making in rugby, the discussion deals with both variables together.

Speed of Decision Making

The results showed a significant improvement in speed of decision making for both the experimental Group 1 and the comparison Group 2 (see Table 3). It can also be noticed that the variability scores within each group, as indicated by the standard deviation, was less on the post-tests. The SD on the pre-test for the experimental group was 2.17*s*, which dropped to .89*s* on the post-test. The SD on the pre-test for the comparison group was 1.51*s* on the pre-test and only .86*s* on the post-test. This means that both groups not only became faster, but also that the subjects within each of the groups were more similar to each other in the speed of their decision making on the post-test.

Table 3

Speed of decision making: Results within groups

	n	Mean	Std. Deviation	*t*	Sig. (2-tailed)
Group 1 Pre-test	30	3.44s	2.17	3.476	0.002*
Post-test	30	2.38s	0.89		
Group 2 Pre-test	38	2.76s	1.51	3.795	0.001*
Post-test	38	1.98s	0.86		

*p = < 0.5

Between group differences are presented in Table 4. Comparison Group 2 was not significantly faster on the pre-test than experimental Group 1 (experimental). However, comparison Group 2 was significantly faster than experimental Group 1 on the post-test. It can be noted that two subjects in Group 1 and four subjects in Group 2 did not take the post-test.

Table 4

Speed of decision making: Results between groups

	n	Mean	Std. Deviation	*t*	Sig. (2-tailed)
Group 1 Pre-test	34	3.57s	2.28	1.887	0.063
Group 2 Pre-test	44	2.77s	1.45		
Group 1 Post-test	32	2.37s	0.900	2.053	*0.044
Group 2 Post-test	40	1.96s	0.79		

*p = < 0.05

Accuracy of Decision Making

The results showed a significant change in the scores for accuracy of decision making for both the experimental Group 1 and the comparison Group 2 (see Table 5). However, the change was in becoming <u>less accurate</u>. In other words, the accuracy of decisions deteriorated significantly for both groups. The mean can be interpreted as the group's average score out of 25 clips.

Table 5

Accuracy of decision making: Results within groups

	N	Mean/25	Std. Deviation	*t*	Sig. (2-tailed)
Group 1 Pre-test	30	4.80 correct	1.80	5.361	0.000*
Post-test	30	2.90 correct	1.70		
Group 2 Pre-test	38	5.10 correct	2.00	6.043	0.000*
Post-test	38	2.80 correct	1.60		

*p = < 0.5

Between group differences showed that the subjects were not significantly different from each other, either on the pre-test or on the post-test (see Table 6). The mean score for accuracy was slightly higher on the pre-test for Group 1 (experimental), but the mean score for both groups on the post-test was almost identical (2.91 correct and 2.83).

Table 6

Accuracy of decision making: Results between groups

	N	Mean/25	Std. Deviation	t	Sig. (2-tailed)
Group 1 Pre-test	34	5.20 correct	2.20	0.393	0.695
Group 2 Pre-test	44	5.00 correct	1.90		
Group 1 Post-test	32	2.90 correct	1.70	0.207	0.837
Group 2 Post-test	40	2.80 correct	1.60		

*p = < 0.05

Discussion of Speed and Accuracy

The results of the test of decision making speed and accuracy showed that players in both groups became significantly faster but also became significantly less accurate. This is not a trade-off with worthwhile benefits. It was interesting to note that the subjects in the comparison group became significantly faster on the post-test than the subjects in the experimental group who had received the special intervention programme.

The reasons why speed but not accuracy of decision making significantly improved for both groups could include the following:

- Both groups had just finished their competitive season when the post-testing was done. All subjects were exposed to many decisions during competitive situations. Hastie (1998) stated that participants gain significantly in terms of competency in all domains from the beginning of the season to the end of the season. . Both groups in this study had experienced decision making under pressure throughout the season and this may have given them the confidence that they could more quickly read and make decisions in the much-less complicated situations illustrated by the video-clip situations on the test. They may have been comfortable going with their “first response” rather than taking time to think about their options.

- Previous research has found that experts make faster decisions when predicting an opponent’s response (Gréhaigne *et al.*, 2001). While the subjects in this study could not be categorised as experts, they had spent all season at full-time rugby academies with formal training programmes, and it can be presumed that they gained expertise. In a study by Paull and Glencross (1997) with baseball batters, expert batters decide faster than novices in predicting ball trajectories. Although the speed of their decision making was much faster, they were not significantly more accurate than the novice group.

McMorris (1997) also found that speed of decision making increased with expertise, but not necessarily the accuracy of decisions. Mascarenhas *et al.* (2005) found that experts were not more accurate in their decisions, they were just a lot more confident in their decisions. It could be that after spending a full season at a rugby academy, all the subjects were more confident about their rugby knowledge. That confidence could have contributed to increased speed in decision making.

- Speed of decision making is also influenced by the number of options from which a subject must choose. Fewer options should make a choice easier and perhaps make decision making faster. The strategies of the two different groups (teams) who participated in this study were not documented. It could be that the style of play adopted by each of the teams during the course of the season led them to see one or more of the four options possible for each video clip, as unlikely or unacceptable from a strategic point of view. This could have limited the number of choices they considered viable, to three or even two options. This would mean that in a sense, they were faced with less complexity in terms of choices on the post-test. This would be compatible with Hick-Hyman Law that states there will be a linear relationship between the reaction time and the number of choices perceived to be available (Hick, 1952; Hyman, 1953).

- Both groups' visual skills improved (data presented later in this chapter). Improved visual skills may have allowed them to scan and "read" the situation on the computer screen more quickly. Although they did not read the situation more accurately, they may have been "finished looking" more quickly because their visual skills were faster and more coordinated (data presented later in this chapter).

- The "cost" of making mistakes on the test was not high and when costs are not high, subjects take risks more easily (Hadfield, n.d.). Although all subjects were directed to make their decisions as quickly and accurately as possible, a quick choice meant the next game situation would be presented. There was no feedback on whether or not the answer was correct. A player who made decisions quickly finished the test quickly (a reward for some players). The accuracy score was not apparent to the player and it was too late to change choices or to slow down and be more careful. During the test, selecting the wrong option did not "cost" the subject anything. During real-time situations the "cost" of making a mistake can be very high.

- Despite claim for face validity, could the criterion against which the decision accuracy was judged be contested? An analysis of the items on which errors were made revealed a random distribution, so no particular test items were isolated as a factor. A second expert coach was contacted to review the content of the decision making test. His "optimal response" for some of the items differed from the first expert. This introduces the possibility that the players in both groups had coaches who may have taught them different styles of play than advocated by the expert coach who developed the test, therefore they would see different answers in tactical situations to be "optimal."

The relationship between speed and accuracy in decision making continues to be explored in Sport Science research. For example, Thomas (1994) stated that accuracy in decision making can be trained and speed will improve with experience. Gréhaigne *et al.* (2001) found that experts tend to have a speed rather than an accuracy advantage over novices in decision making. Thomas (1994) also associated the accuracy and speed of decision making with procedural knowledge. During this study only the declarative knowledge of the subjects was tested. Both groups achieved a significant improvement in their declarative knowledge (data presented later in this chapter). Unfortunately, it did not have an impact on their decision-making accuracy, which deteriorated significantly.

Starkes and Lindley (1994) reported success in training both the speed and accuracy of decision making. Villepreux (1993) recommended that programmes to enhance tactical decision making in high-strategy games include two aspects:

1. The development of a tactical understanding of game situations while learning to read and interpret game situations.

   The two variations of game analysis plus the tactical rugby discussions were provided by the coach in an effort to increase his players' tactical understanding of rugby. Although he attempted to achieve the goal, intervention was not successful as measured by the test developed for this study, since the accuracy of their decisions deteriorated on the post-test.

   That the post-test speed of the control group was significantly faster than that of the experimental group could be interpreted as a positive sign. Perhaps they did experience a slight increase in their tactical understanding, which may have had a "braking effect" on the acceleration in decision making speed that initially accompanies an increase in expertise.

2. The development of individual technical skills in relation to the tactical challenges and pressure experienced during actual game play.

   This was one aspect of this research that was out of the control of the investigator. Both groups participated in rigourous rugby skill development programmes, but there was no opportunity to record what exactly went on in any session in terms of the development of tactical understanding. The teams drawn from each group did play in the same league and their level of technical development was considered to be similar.

How can decision making be trained? Smith (n.d.) recommended that it can be done by the exposure to many different scenarios. The Starkes and Lindley (1994) study found that video simulations were effective for training decision making but they were unclear about how to measure transfer to the field. In this study, three methods were employed to attempt to influence speed and accuracy of decision making among players in the experimental group. Players in the comparison group did not experience these methods.

1. Game analysis: Jenkins, Morgan, & O'Donoghue, (2007) advocated video-based game analysis sessions as a means to increase players' knowledge and understanding of the game. Only the experimental group in this study made use

of game analysis as a strategy to develop tactical understanding of rugby. The two uses of game analysis (group presentation and individual analysis) did not appear to have an impact on the decision making accuracy of the subjects in the experimental group.

2. Tactical discussions: Hadfield (n.d.) described decision making in fast-moving dynamic situations as intuitive decision making. He stated that intuitive decision making can be enhanced through discussions with players that explore the reasons behind tactical decisions and by showing players what to do in a variety of tactical situations. Players in the experimental group in this study did participate in this kind of intervention activity, while members of the comparison did not. However, the discussions as conducted in this study did not appear to have an impact on the accuracy of decision making.

3. Rugby rule discussions: The decision making skill can be improved by increasing the knowledge of players through studying matches, game law, plays and game plans (Grimison, 2006). Players in the experimental group were involved in special lessons on the laws of rugby (see results of declarative knowledge intervention later in this chapter).

In this research, the intervention programme cannot claim to have contributed to an increase in the speed of decision making by the experimental group, since the control group experienced the same significant increase in speed. The intervention programme also had no positive effect on the accuracy of decisions making, since both groups reflected similar patterns of significant deterioration in the accuracy of their decision making.

There is some speculation from literature as to what type of practice might improve decision making (Abernethy, 1996). According to Grimison (2006) decision making is trainable and complementary to the technical skill development. It can be concluded from this study that a programme designed to improve both the speed and accuracy of players' tactical decision making cannot only rely on game analysis, video-based feedback, and tactical discussions to raise declarative and procedural knowledge. Additional interventions, such as on-field drills and mini-game experiences appear to be critical to the development of tactical understanding. Having said that, it also must be noted that the kinds of drills and on-field practice activities provided to the subjects in both groups, as part of their regular rugby academy programme, were not effective in significantly improving the accuracy of their decision making, as measured by the test in this study.

Research Question Two

2. Will the declarative knowledge of u/20 rugby players be improved following participation in a 16-week programme designed to develop tactical understanding?

The mean scores for each group on the written test (50 multiple-choice questions) represent the measurement of declarative knowledge. Both the experimental Group 1 and the comparison Group 2 achieved significant improvements in their scores on the test of declarative knowledge (see Table 7). The mean can be read as a score out of fifty.

Table 7

Declarative knowledge: Results within the groups

	n	**df**	**Mean/50**	**Std. Deviation**	***t***	**Sig. (2-tailed)**
Group 1 Pre-test	32	31	27.90 correct	4.3	-4.569	0.000*
Post-test	32		31.60 correct	5.7		
Group 2 Pre-test	40	39	27.80 correct	3.9	-3.037	0.004*
Post-test	40		29.20 correct	4.4		

*p = < 0.5

There was not a significant difference between the two groups on the pre-test of declarative knowledge, however, experimental Group 1 scored significantly higher than comparison Group 2 on the post-test, indicating that the subjects in the experimental group achieved significantly greater gains in their declarative knowledge than subjects in the comparison group (see Table 8).

Table 8

Declarative knowledge: Results between groups

	n	df	Mean/50	Std. Deviation	t	Sig. (2-tailed)
Group 1 Pre-test	36	84	28.00 correct	4.2	0.315	0.754
Group 2 Pre-test	50		27.80 correct	3.6		
Group 1 Post-test	32	70	31.60 correct	5.2	2.082	0.041*
Group 2 Post-test	40		29.20 correct	4.4		

*p = < 0.05

Discussion of Declarative Knowledge

Declarative knowledge refers to a cognitive understanding of rugby and includes knowledge about facts and rules (Hadfield, n.d.). Declarative knowledge can directly contribute to the decision making process when there is no time pressure. A greater declarative knowledge base also should have a positive impact on the development of procedural knowledge, which in turn should lead to more accurate decision making when time pressure is present (Gréhaigne & Godbout, 1995). The premise for this association is that the larger the player’s knowledge base, the more accurately he/she can identify and recognise regularities and constraints, and ultimately make the optimal decision for the situation.

The method for assessing declarative knowledge was a traditional written format and there was no time pressure. The test of decision making accuracy did have a speed element to it. The fact that neither group improved in the accuracy of their decision making despite improvements in declarative knowledge is not sufficient to discard declarative knowledge as one dimension of decision training. During this study both groups achieved a significant improvement in their declarative knowledge base, but deterioration in the accuracy of their decision making. It could be that the procedural knowledge needed to support accuracy in decision making takes years to develop, not just one season, and that improvements in declarative knowledge are just the first step. It also must be noted that the mean scores of both groups are low when converted to percentages. The post-test mean for the experimental group were 31+ correct out of 50 (62%) and for the comparison group, 29+ out of 50 (58%). These scores on a multiple choice test are not impressive and are an indication that all of the players involved in this study still have quite a bit to learn about rugby. Their declarative knowledge base may still not be sufficiently strong to support accurate decision making.

There are some possible explanations to account for both groups achieving significant improvements in their declarative knowledge:

- Both groups experienced a full competitive season in the same league, during which time players had a similar opportunity to expand their knowledge base of rules and facts about how rugby is played. When players are involved in situations on the field they generate memory representations that can be stored as cognitive (declarative) knowledge as well as procedural knowledge (Iglesias *et al*., 2005).

- Both teams did receive coaching during the season, which might have made a positive contribution to their declarative knowledge base. Coaches can ask players questions to trigger awareness and to ensure they understand. After a hockey group followed a game sense training approach, it was found that they scored significantly higher in both the declarative and procedural knowledge than a group that did not followed a game sense approach (Turner & Martinek, 1999).

The significantly greater improvement of experimental Group 1 in their declarative knowledge could be attributed to the following characteristics of the intervention programme:

- Game analysis. The subjects in the experimental group not only had to analyse their games, but they also had to make short oral presentations to their teammates, identifying strengths and weaknesses in performance. This meant that they had many more opportunities to look at rugby and to discuss rugby than the subjects in the comparison group. Thomas (1994) stated that declarative knowledge can be enhanced by the explanation of strategies, the discussion of principles of play and by watching other teams perform and discussing it.

- Rugby rule discussions. Thomas (1994) also recommended the learning and discussion of rules as a means to expand declarative knowledge.

Gréhaigne and Godbout (1995) took the position that in order to improve declarative knowledge, the content of declarative knowledge had to be systematically and formally identified. According to Williams, Davids and Williams (1999), the declarative memory consists of information about "what to do" and procedural memory contains knowledge regarding "how to do it". Both kinds of knowledge are crucial for skilled performance. The players in this study were all u/20 (relatively inexperienced) and did not have an impressive declarative knowledge base at the beginning of this study. Despite the effective interventions to improve that knowledge base by the coaches of both groups, and despite the significantly more effective intervention presented to the experimental group, there was no positive impact on the accuracy of decision making for the subjects in either group as measured during the post-tests in this study.

During a study done by McPherson (1999), differences between novices and experts were evaluated based on knowledge content, structures in problem representation, solution processes and support strategies. The results indicated that experts made better decisions. The superior decision-making abilities of experts compared to intermediate or novice players, were attributed in part to a more extensive declarative knowledge structure and procedural knowledge base that support a flexible approach to problem solving (Gréhaigne *et al*., 2001). Experts display better problem representation, because they access only the correct and necessary knowledge needed to perform a task. The development of expertise clearly requires more than a one-season effort. It may have been too ambitious to think it is possible that the gains in declarative knowledge would have had an impact on the accuracy of decision making at this early stage in the development of these players.

Research Question Three

3. Will the visual skills of u/20 rugby players be improved following participation in a sports visual skills training programme, integrated into a programme designed to develop tactical understanding?

The scores on the visual skills test battery showed that subjects in both experimental Group 1 and comparison Group 2 achieved significant improvements in their visual skills as measured by a total score out of 50 on the sports vision test battery following a 12-week period (visual training was only for 12-weeks in contrast with rest of the intervention period of 16 weeks), during which time the experimental group received a 12-session sports visual skills training programme (see Table 9).

Table 9

Visual skills: Results within the groups

	n	df	Mean	Std. Deviation	*t*	Sig. (2-tailed)
Group 1 Pre-test	36	35	30.50 pts	5.80	-4.771	0.000*
Post-test	36		33.70 pts	5.10		
Group 2 Pre-test	34	33	25.20 pts	5.70	-7.500	0.000*
Post-test	34		30.50 pts	4.70		

*p = < 0.5

Experimental Group 1 scored significantly higher than comparison Group 2 on both the pre-test and the post-test of visual skills (see Table 10). This makes it impossible to compare the scores between the groups since it appears that the players in the experimental group had superior visual skills prior to this study.

Table 10

Visual skills: Results between groups

	n	df	Mean	Std. Deviation	*t*	Sig. (2-tailed)
Group 1 Pre-test	36	85	30.30 pts	5.60	4.628	*0.000
Group 2 Pre-test	34		24.90 pts	5.30		
Group 1 Post-test	36	68	33.70 pts	5.10	2.740	*0.008
Group 2 Post-test	34		30.50 pts	4.70		

*p = < 0.05

Discussion of Visual Skills

It is not possible to claim that the sports visual skills training programme made a significant contribution to the development of the visual skills of players in the experimental group, since both groups achieved a significant improvement in their performance on the sports vision tests battery.

There is evidence that athletes involved in organised sports have better visual abilities and more efficient visual skills than non-athletes (Melcher & Lund, 1992). It is believed that visual skills have an impact on sport performance and that successful athletes demonstrate superior visual skills levels. According to Melcher and Lund (1992), the visual system plays a crucial role in sports performance. However, what is not clear is whether experts happen to have better vision, or whether by training their visuals skills, their expertise can be enhanced. Previous research is equivocal about whether or not improving visual function will improve sports performance (Abernethy & Wood, 2001).

Expert advantage has been attributed to superior anticipation, pattern recognition and ability to interpret information, rather than specifically to superior visual skills (Abernethy & Wood, 2001). There is a direct relationship and interaction between the eyes and the brain in terms of judgments about space and timing (Leviton, 1992). Visual perceptions of time and space are crucial for tactical decision making. Anticipation relies on picking up the correct cues in advance. According to Farrow (2001), there are two basic sources of information that allows early and accurate anticipation of opponents' behaviour. Firstly, there is kinematic information that is available from an opponent's movement pattern. Secondly, there is contextual information that includes knowledge about the situational aspects of performance. Results of a study testing cricket batsmen indicated that the more expert batsmen have a greater ability to successfully use relevant cues than less expert batsmen (Penrose & Roach, 1995). One component of effective decision making is controlling attention, which includes ignoring some cues to focus only on relevant cues. Theoretically, improvements in visual skills could support improvements in anticipation since the player would have more control over exactly where he/she looks, when and for how long.

Abernethy and Wood (2001) contended that the effectiveness of a visual training programme depends on the following key assumptions:

1. That the visual skills selected are related to the sports performance.
2. That the visual skills selected can be trained.
3. That if the visual skills improve, that improvement will transfer to improve sports performance.

Within this study, the visual skills selected were part of a formal sports vision testing battery. It is possible that the battery is not sufficiently specific to rugby. Abernethy and Wood (2001) were skeptical that visual skills can be trained. The fact that there were improvements in visual skills performance for the subjects in this study, regardless of participation in a visual skills training programme, suggests that there is a lot more to be learned about the training and development of visual skills. Transfer to rugby performance was not measured in this study, so it is not possible to speculate about the impact of visual skills training on game play.

The advantage of visual skills training would be in its contribution to helping players "read the game" (Greenwood, 2000). This relationship between visual skills and visual perception was the rationale behind conducting the visual skills training programme in this study out on the field as part of practice sessions. The programme was dynamic and rugby-specific in the ways in which visual skills were practiced. Of course, both groups followed a very intense rugby training programme, including daily skill training sessions. It is possible that both approaches had a positive impact on the player's visual and anticipation skills. According Den Duyn (1996), the ability to read the game is possible to develop through quality coaching. Assuming that both academy teams received quality coaching, it is possible that no additional benefit was brought to the rugby training by the visual skills intervention programme.

Additional Insight into Visual Skills

Grimison (2006) believed that tactical decision making can be enhanced by undertaking sports vision training, if that training develops visual awareness by teaching players to scan for cues and then react to them. Previous studies have found that experts do display better visual awareness and anticipation skills and pattern recognition (Gréhaigne *et al.*, 2001). During the visual skills intervention programme implemented in this research, visual skills such as peripheral vision, depth perception, visual memory and hand-eye coordination/coincident timing were emphasised. Visual skills training sessions were dynamic and sport-specific. The sequence of 12 sessions started with basic visual skills training activities. Difficulty was progressively increased with time pressure, pressure to make choices and decisions, and performing more than one skill at a time. A closer look at the results of the sports vision tests reveals that certain visual skills changed more than others. The improvements were not consistent between the two groups, indicating that "sports vision" may be a general term and that a combined score on a visual skills test is not a good indicator of which specific visual skills are improving (see Table 11).

Table 11

Improvements in visual skills

Visual Skills Showing Improvement for Experimental Group 1	**Visual Skills Showing Improvement for Comparison Group 2**
Pursuits	Static & dynamic visual acuity
Vertical saccades	Peripheral awareness(left & right)
Near-far saccades	Near-far saccades
Coincident timing	Horizontal saccades
Visual memory	

In order to take a closer look at the individual visual skills, the pre- to post-test changes in scores were identified and the frequencies of subjects achieving either a “good” or “very good” rating on each skill was calculated as a percentage of their group (see Appendix H). It was then possible to create figures to illustrate pre- to post-test changes in those skills for both the experimental and comparison groups. Figure 6 illustrates changes in visual acuity (central vision) and peripheral awareness (peripheral vision). It can be noticed that there was a slight drop in the number of subjects in the experimental group achieving a “good or very good” rating on either static or visual acuity.

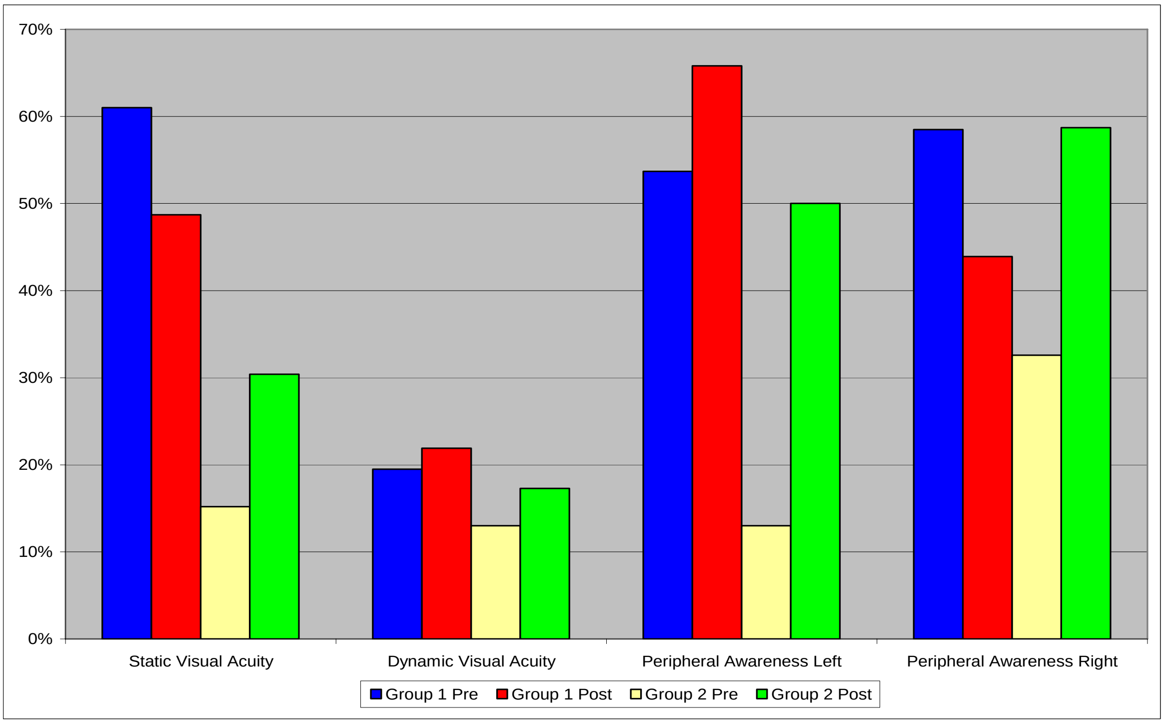

Figure 7

Between group comparisons of changes in visual acuity and peripheral awareness

It is rather difficult to explain the drop in static visual acuity. The light conditions were constant during pre-and post-testing, so that can be ruled out as a factor. A lack of motivation by the subjects taking the test is always possible, but was not noticed during the post-test. The change in static visual acuity was an improvement for the comparison group. It could be than subjects tried harder on the post-test. The scores on dynamic visual acuity remained similar for both groups.

The improvements in peripheral vision on both the right and the left displayed by the comparison group were not matched by the experimental group, who had lower scores on the post-tests for the right side. Processing of information from the peripheral visual fields is important for successful performance (Erickson, 2007). It is a visual skill that varies according to a variety of factors, such as anxiety, motivation, etc. It is not known why the subjects in the comparison group achieved such an improvement, but it is to their advantage during tactical decision making to be able to gather information from the peripheral as well as central vision.

Figure 8 is an illustration of changes recorded for the five visual skills that comprise ocular motility. Ocular motility refers to the subject's ability to use the eyes as a team to track objects and people as well as to scan the environment for cues.

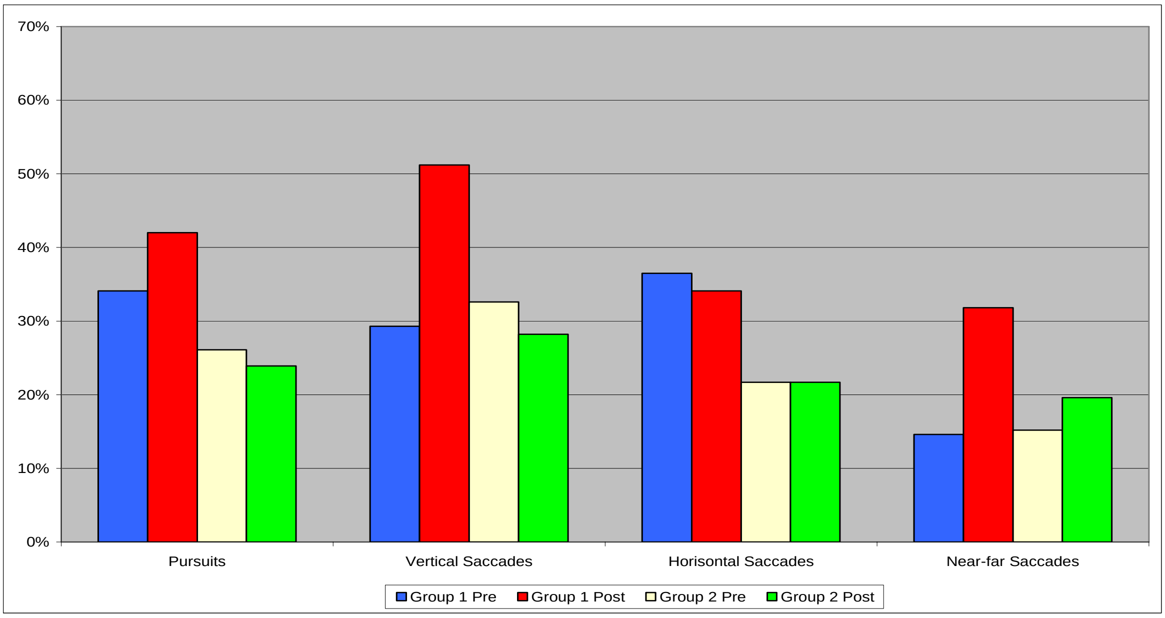

Figure 8

Between group comparisons of ocular motility

Subjects in the experimental group improved on their rapid vertical and near-far saccadic eye movements, while subjects in the comparison group did not. The experimental group also improved in the pursuits, while the comparison group did not. During the visual skills intervention programme, the researcher did try to stimulate practice of visual search patterns through stimulating sport-specific rugby exercises (Appendix E &

F). Many of these activities included small balls that traveled at different speeds. These activities may have provided the stimulus for an improvement in saccadic eye movement. There was no particular emphasis on tracking slow moving objects or people, so the lack of improvement in pursuits may be understood. The reason for the sharp drop in pursuits among subjects in the comparison group is unclear.

Figure 9 is an illustration of changes in coincident timing and visual memory recorded in pre- to post-test calculations. It can be observed that the rugby players do not test a high score on coincident timing. Their ability to intercept an object is not well developed. Rugby is played with a relatively large ball and when intercepting an opponent on a tackle, the opponent does present a large target, but the prediction of the path of the ball or the opponent should be accurate. The drop in frequency for the experimental group may indicate that insufficient practice in coincident timing was provided by the visual skills training programme.

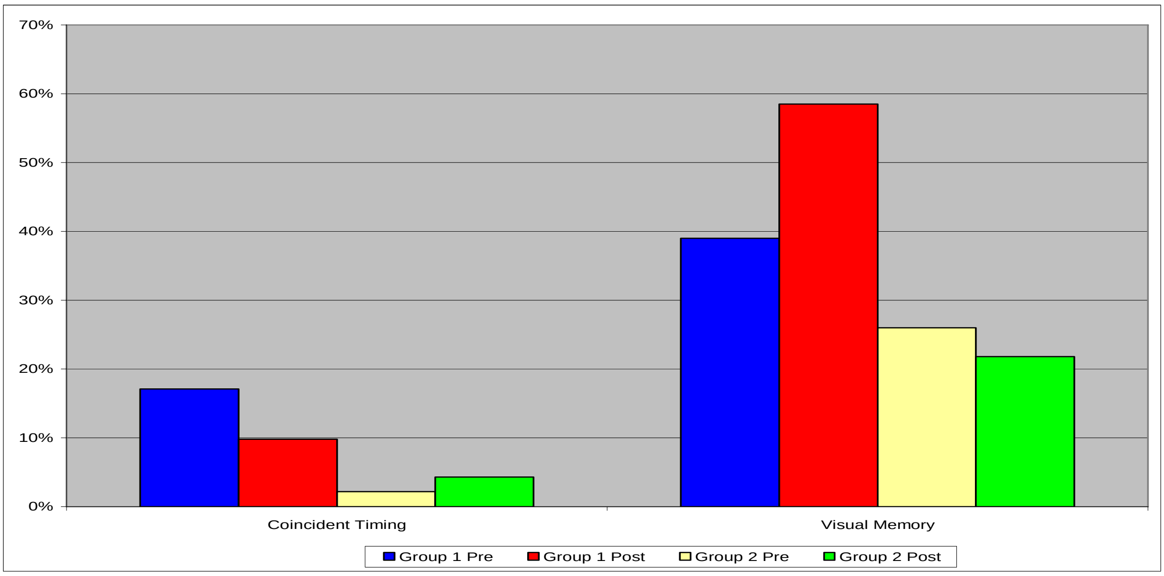

Figure 9

Between group comparisons of coincident timing and visual memory

The improvement in visual memory by the experimental group may be taken as positive feedback that the kinds of practice activities provided during the visual skills training sessions may have made a unique contribution. Visual memory plays an important role during visual scanning, allowing a player to remember the position of objects and to recognise patterns of plays, which can have a positive influence on decision making (Knudson & Kluka, 1997). The frequency of subjects whose raw scores placed them in the "good to very good" categories for visual memory, did improve for the experimental group (red bar). This is regarded as a positive sign.

If sports visual skills training sessions are to be included in formal rugby training programmes, the impact of visual skills training must be clearly demonstrated. This was not achieved in this study. The number of sessions (12 sessions distributed once a week for the first 12 weeks of the 16-week intervention programme) may have been too few. Certainly the activities included in each session must be reviewed.

Conclusion

The components of successful sport performance have been identified as the technical, tactical, physical and psychological aspects (Hadfield, n.d.). Decision making forms part of the tactical component. Tactical decision making is based on cognitive processing, which is a function of perception, memory and knowledge. In this study, selected aspects of tactical decision making were isolated for inclusion in an intervention programme. The intervention programme, implemented over a period of 16 weeks, targeted an improvement in the speed of cognitive processing (reflected in the speed and accuracy of decision making), the declarative knowledge base and the visual skills of u/20 rugby players.

Two significant differences were recorded between the experimental and the comparison groups. The first was the significant improvement in speed accompanied by deterioration in the accuracy of their decision making. This may be a characteristic of an intermediate level of rugby expertise as players push to become faster at processing information. The cost in terms of accuracy in decision making could be a function of this process. The second was the significantly greater improvements in declarative knowledge of subjects in the experimental group when compared to the subjects in the comparison group. It appears that calculating game statistics, game analysis, discussions of tactics and rule discussions may have supported the development of declarative knowledge, which could ultimately make a positive contribution to decision making.

Chapter Five

Conclusions and Recommendations

In this final chapter, conclusions about this study will be drawn and the problems experienced will be highlighted. Recommendations for future research will then be made.

Conclusions

The purpose of this study was to determine the impact of a multidimensional intervention programme to develop tactical understanding in rugby on the speed and accuracy of decision making, the declarative knowledge and the visual skills of u/20 rugby players. The results of the study were that the subjects who participated in the intervention programme did not achieve significant differences on any of the targeted outcomes, when compared to subjects from a similar rugby academy. This was a disappointing outcome, yet important for designing future efforts to enhance tactical decision making. Four of the five intervention strategies implemented (all strategies except the visual skills training) involved the subjects' thinking about tactical situations and rules, then verbalising their thoughts as well as listening to the thoughts of others. Experts' tactical responses in game situations have been found to be consistent with their verbal explanations of what they should do and when they should do it (McPherson & Kernodle, 2003). This suggests that verbalisation can be an effective technique for improving tactical understanding. It can be concluded that, in this study, the four specific verbal strategies were not effectively implemented.

Conclusions about the potential weaknesses in the various dimensions of the intervention programme are presented below:

- Rugby rule discussions

  Perhaps there was not a sufficient amount of time spent in these discussions or perhaps the discussions were not sophisticated enough to challenge the players' cognitive development. Discussions should be structured around questions and players should have the opportunity to share their own points of view. Although these sessions were intended to be discussions, it is possible that the players were not accustomed to sharing their own views. It may take time to teach players how to engage in discussions. Although the optimal format for the inclusion of discussions of tactics and rules may not have been implemented in this study, the cognitive verbal involvement of players is still a reasonable focus for the content of an intervention programme.

- Video-based tactical rugby discussions, game analysis and statistical analysis of individual players

  The viewing of actual video recordings of game performance as the focus for discussions was found to be an effective method for enhancing tactical understanding in high-strategy open-skill sports (Janelle & Hillman, 2003). The tactical rugby discussions, game analysis and statistical analysis discussions in this study all used video recordings of the actual rugby game performances of the subjects in the intervention programme. Personalising the discussions about tactics in game situations is proposed to increase the meaningfulness of the situations and make them easier to remember. Once again, the sophistication of the discussions may not have challenged the players, and/or the players may not have been accustomed to participating in discussions. The ability to select the critical cues and relationships in game play is also a special ability that the players may not have mastered. The coach was an expert and his comments and the video clips he selected can be assumed to have been appropriate, but the players may have needed much more practice to identify important tactical and technical events in a game. It should not be concluded that these types of interventions would not be successful in the future.

- Visual skills training

  The lack of significant difference between the visual skills post-test scores of the subjects in the intervention group compared with the players in the comparison group is consistent with the position of Abernethy and Wood (2001). Subjects in both groups achieved significant improvements in their visual skills, supporting the position that visual skills cannot be specifically trained, but will rather improve naturally within the context of well-designed practice sessions. However, there is sufficient disagreement in sport science about sports vision and visual skills training to continue to investigate the topic. The critical role of visual search in decision making has been documented (Williams *et al*., 1994). It can be noted that in this study, the visual memory of players in the experimental group improved. This is a positive sign because the ability to recall patterns of play is critical for expert players (Allard, 1982).

The intervention programme implemented in this study was allotted a limited number of sessions as part of the formal training schedule of the experimental group. It is possible that the amount of time was not sufficient. Subjects in both the experimental and comparison groups became faster but less accurate in their decision making, they showed significant improvements in their knowledge of the rules and also achieved significant gains in their visual skills. However, there were no significant differences between the two groups. Both academy programmes could be considered to be successful, and the additional training afforded to the experimental group appears to have been insufficient to give them an additional advantage.

The subjects in this study were neither experts nor novices. Most of the research has contrasted these two extremes, therefore is it not clear at what point in development it is reasonable to expect significant gains in tactical decision making. It is known that expertise takes many years to develop and it may have been too ambitious to expect changes in just one season. Hadfield (n.d.) also made the point that decision making can effectively be taught through discussions and demonstrations, provided that players also have the opportunity to be involved in actual on-the-field practice situations. Perhaps more attention should be paid to making direct connections between discussions of tactical and technical aspects of rugby and the content of the practice sessions.

Problems

Some of the problems encountered when implementing this study might better be labelled as “challenges” since they are characteristics of research with intact groups in real-world settings that either must be acknowledged as limitations or somehow managed to reduce their impact on the results of the research. These challenges included:

- All of the subjects participated in a full competitive season during the course of this study. Players had different amounts of playing time, some sustained injuries, and some players changed positions during the season. Although both academy teams did play in the same league, there may be a variety of unidentified variables that could have affected their post-test performances.

- There were differences between the two rugby coaches in terms of how they approached the teaching of skills and of tactics during practice sessions. Each academy had only one coach who designed their practice sessions. Allen (2006) completed an analysis of the coaching behaviours of these two coaches. Their comparison between their two styles is presented in Table 12. Coach 1 was the coach for the intervention programme.

Table 12

The coaching behaviours of the two coaches during practice sessions (Allen, 2006)

Variables for Analysis	**Average % of time spent per practice session**	
	Coach 1	**Coach 2**
Type of activity		
• Players drills/repeat actions (direct styles)	52%	43%
• Players make decisions (indirect styles)	48%	57%
• Other type of activity	0%	0%
Modeling		
• Specific modeling	52%	0%
• No specific modeling	48%	100%
Feedback & instruction during activity		
• Comments to group or team	77%	73%
• Comments made to individuals	23%	16%
• No comment	0%	11%
Feedback & interaction after activity		
• Comments to group or team	64%	56%
• Comments made to individuals	16%	36%
• No comment	20%	8%
Cognitive focus of activity		
• Skill technique	91%	26%
• Tactics	9%	74%
• Other	0%	0%

It is interesting to note that the coach for the intervention programme used 91% of his on-field practice time for skill technique focus, while the coach of the comparison team used 74% of his on-field practice time for tactics. This could be because the comparison team had no technical, tactical, or rule discussion sessions as a separate part of their training schedule, while the experimental group did. The only other noticeable difference was in the use of modeling, where the comparison group coach never used any kind of modeling (demonstrations).

- Allen (2006) proceeded to analyse the coaches' behaviours during tactical and skill-focused activities, in terms of the style of coaching (see Table 12). The coach of the experimental group used a balance of indirect and direct styles, while the coach of the comparison group favoured the indirect style for the tactical learning activities and the direct style for the skill learning focus activities. He observed that the coach of the intervention group combined decision making with skill practice in order to encourage players to link their skill learning to the tactical use of the skills. He suggested that this was similar to the "new" way of coaching – Teaching Games for Understanding.

Table 13

A comparison of coaching styles (Allen, 2006)

Style of Coaching	**Coach 1**	**Coach 2**
Tactical learning focus	**9%**	**74%**
Players make decisions (indirect style)	7%	54%
Players drill/repeat actions (direct style)	2%	20%
Skill learning focus	**91%**	**26%**
Players make decisions (indirect style)	41%	3%
Players drills/repeat actions (direct style)	50%	23%
Other learning/practice activities	**0%**	**0%**

- The academy coach for the experimental group led all the discussions of rugby tactics, game analysis and individual player statistical analysis sessions for his squad. He decided what cues to emphasise and the criteria for a "correct" as opposed to an "incorrect" tactical decision as presented on the videotape of a game. It could be that his emphasis was not compatible with the emphasis of the expert that assisted in creating the test of declarative knowledge used in this research.

- There were several players who did not take part in the post-tests. Their results could possibly have influenced the final outcome of this study.

Some of the problems encountered when implementing this study could be addressed in future studies of this type:

- The rugby video clips of critical situations may not have been "real" enough to get the players highly motivated to make their best choice of what option to select. For example, the projection was on a computer screen and the subjects could not completely see where all the open spaces were on the field. It would be interesting to try a more realistic environment, such as virtual reality, to see if that would contribute to positive motivation of the players.

- The visual skills sessions did not appear to have any impact on the players in the experimental group. While it is tempting to conclude that more sessions might have had an influence, the investigator also believes that the actual content of the training sessions needs review. Although video simulation has proven effective in some cases, the aim of this study was to find a way to train visual skills on the field as an integrated part of actual training sessions. New ideas for low-tech as opposed to a high-tech training options are needed.

Recommendations

The critical role of decision making in rugby makes it an area worthy of research in the future. Based on the experience gained in this study, the following recommendations are made for future field-based research with intact groups:

- Use of video simulations: There has been success reported in the past with video simulations. Additional study in this direction is warranted.

- Research on coaching styles: There is a lack of knowledge about how the coaching styles of different coaches might influence the tactical understanding of rugby. Since the coach spends so much time with the players and has such a strong influence on their development, it is important to know what styles are most conducive to the development of players as tactical decision makers. It is unlikely that any intervention programme could be successful if the coaching styles experienced by the players are not compatible with decision training.

- Research conducted at different levels of expertise: What the results will be if the same tests will be used but with different subjects, intermediate and expert players.

- An individual case study approach: A non-experimental approach might be effective in which the tactical understandings of individual players are assessed at several intervals during a season. These assessments could include speed and accuracy of decision making, as well as declarative knowledge base and even their visual skills. Interviews could also be conducted with each player to gain insight into the ways in which his/her thinking about tactics and rugby might be changing.

- A group case study approach: A case study with a single academy or intact team might encourage a more comprehensive approach to the development of tactical decision making. The head coach might be willing to allow specialist coaches to conduct the game analysis sessions, which, for example, could raise the quality of the analysis from a tactical learning point of view. If improvements are achieved in objective measures of decision-making speed and accuracy, declarative knowledge and/or visual skills, transfer to the field of play might be assessed using game analysis. Changes in decisions made in certain situations (performance indicators) could reveal whether or not application to rugby is occuring.

- Correlation studies: More information about the following relationships could help guide coaches in designing the content of their training programmes:

The relationship between declarative knowledge and procedural knowledge

The relationship between the development of skill and the development of the tactical understanding

The relationship among the development of skill, tactical understanding and visual skills in rugby

- Longitudinal studies: If it takes years to develop expertise, then insight into gaining expertise in tactical decision making may only be revealed if changes in a subject or group of subjects are tracked over a period of several years.

Final Remarks

Previous research indicated that it takes years to develop expertise. The results of this study are compatible with that point of view. Intervention over the course of 16 weeks was not able to make any significant changes in the selected components of tactical decision making, declarative knowledge or visual skills in rugby. It was encouraging that a significantly greater improvement was achieved in the declarative knowledge of the subjects in the experimental group.

Previous research suggests that tactical decision making relies on the development of integrated cognitive processing. The results of this study are compatible with that interpretation since no effect was achieved when only selected aspects of cognitive processing were targeted for an intervention programme. Comprehensive intervention programmes in the future should include training to improve observation, interpretation of visual cues, anticipation, the memory processes, the development of procedural knowledge, as well as visual skills and declarative knowledge. The ultimate assessment of the success of any programme will, of course, be the transfer of tactical understanding to decision making during game performance.

References

Abernethy, B. (1991). Visual strategies and decision-making in sport. *International Journal of Sport Psychology*, 22:189-210.

Abernethy, B. (1993). The nature of expertise in sport. Proceedings: *The 7th International Society of Sport Psychology Conference,* Lisbon, Portugal, 18-26.

Abernethy, B. (1996). Training the visual-perceptual skills of athletes. *The American Journal of Sports Medicine,* 24 (6):S89-S92.

Abernethy, B., Neal, R., Engstrom, C. & Koning, P. (1993). What makes the expert sports performer better than the novice? *Sports Coach,* April – June: 1-7.

Abernethy, B. & Wood, J.M. (2001). Do generalized visual training programmes for sport really work? An experimental investigation. *Journal of Sport Sciences,* 19:203-222.

Allard, F. (1982). Perception and sport skill. *Coaching Science Update.* pp. 52-55.

Allen, T. (2006). *Methods of Coaching to Improve Decision Making in Rugby*. Unpublished M. Thesis, Stellenbosch University, Stellenbosch, South Africa.

Bar-Eli, M. & Tractinsky, N. (2000). Criticality of game situations and decision making in basketball: an application of performance crisis perspective. *Psychology of Sport and Exercise,* 1:27-39.

Bazanov, B.; Haljand, R. & Võhandu, (2005). Offensive teamwork intensity as a factor influencing the result in basketball. *International Journal of Performance Analysis,* December, 5 (2):9-16(8).

Boddington, M.K.; Lambert, M.I. & Waldeck, M.R. (2003). The analysis of skilled performance and game parameters during league field hockey matches. *International Journal of Performance Analysis,* December, 3 (2):121-129(9).

Bompa, T.O. (1999). *Periodization, theory and methodology of training.* Champaign, IL: Human Kinetics.

Bressan, E.S. (2003). *Motor learning – A sport science perspective*. Die Boord, RSA: Winning Spirit Sport Education.

Bruce, L.; Farrow, D. & Young, W. (2004). Reactive agility – the forgotten aspect of testing and training agility in team sports. *Sports Coach*, 27 (3):34, 35.

Burroughs, W.A. (1984). Visual simulation training of baseball batters. *International Journal of Sport Psychology*, 15:117-126.

Crouch, H. (1992). *Netball Coaching*. London: A & C Black.

Den Duyn, N. (1996). Why it Makes Sense to Play Games! *Sports Coach*, Spring, 19 (3): 6-9.

Dillon, J.M.; Crassini, B. & Abernethy, B. (1989). Stimulus uncertainty and response time in a simulated racquet-sport task. *Journal of Human Movement Studies*, 17: 115-132.

Drawer. S. (2002). Data analysis. *FHS*, July, 16:19, 20.

Eaves, S.J., Hughes, M.D. & Lamb, K.L. (2005). The Consequences of the introduction of professional playing status on game action variables in international Northern hemisphere rugby union football. *International Journal of Performance Analysis*, November, 5 (2):58-86(29).

Eisele, P. (2004). Judgment and decision making: Expert and novices' evaluation of chess positions. *Perceptual and Motor Skills*, 98: 237-248.

Ericcson, K., Krampe, R .& Tesch-Romer, C (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, 100(3): 363-406.

Erickson, G. (2007). *Sports Vision*. St. Louis, MO: Butterworth Heinemann Elsevier.

Evans, G., Horgan, D. & James, G. (1979). *Thinking rugby: The London Welsh way*. London: George Allen & Unwin.

Farrow, D. (2001). Anticipation in time-stress ball sport. *Sport Coach*, 24:26-27.

Farrow, D. (2004). How skill acquisition research can influence practice. *Ausport*, August, 18-19.

Farrow, D. (2007). "Predictors of skill expertise in team sports: A netball case study". [http://www.rugbycanada.ca/content_files/07._Skill_Acquisition_Farrow.pdf]. Retrieved 26 June, 2007.

Farrow, D. & Jones, C. (1999). Strategic transfer between sports: Implications for coaches. *Sports Coach*, 22(2):32-33.

Franks, I.M. & Miller, G. (1991). *Journal of Sports Sciences*, 9(3):285-297.

French, K.E. & Nevett, M.E. (1993). The development of expertise in youth sport. In J. Starkes & L. Allard (Eds). *Cognitive issues in motor expertise*, pp 255-270. London: Elsevier Science Publishers.

Glencross, D.J. & Cibich, B.J. (1977). Decision analysis of games skills. *Australian Journal of Sports Medicine,* 9: 72-75.

Greenwood, J. (2000). *Think Rugby*. London: A & C Black.

Gréhaigne, J.F., Godbout, P. & Bouthier, D. (2001). The teaching and learning of decision making in team sports. *Quest*, February, 53(1):59-76.

Gréhaigne, J.F, Godbout, P. (1995). Tactical knowledge in team sports from a constructivist and cognitivist perspective. *Quest*, November, 47(4):490-505.

Gréhaigne, J.F., Godbout, P. & Bouthier, D. (1999). The Foudations of tactics and strategy in team sports. *Journal of Teaching in Physical Education*, January, 18(2):159-174.

Grimison, M. (2006). "Decision Making: How to Periodise." [http://aru.rugby.com.au/verve/_resources/How_to_periodise_decision_making_into_your_annual_plan_-_M_Grimison_2006.pdf]. Retrieved 15 January. 2006.

Hadfield, D. (n.d). "Understanding decision-making in rugby". [http://www.rfu.com/pdfs/technical_journal/decisionmaking.pdf]. Retrieved 15 January, 2006.

Hastie, P.A. (1998). Skill and tactical development during a sport education season. *Research Quarterly for Exercise and Sport*, December, 69(4):368-379.

Hick, W.E. (1952). On the rate of gain of information. *Quarterly Journal of Experimental Psychology,* 4:11-26.

Hollier, J. (2005). Rugby Sense and Skill Acquisition: the psychology of coaching “skill”. *Coaching Update,* July, (19)2: 22-24.

Housner, L.K. & French, K.E. (1994). Future Directions for research on expertise in learning, performance, and instruction in sport and physical activity. *Quest,* 46:241-246.

Hughes, M.D. & Bartlett, R.M. (2002). The use of performance indicators in performance analysis. *Journal of Sports Sciences*, 20:739-754.

Hughes, M. & Wells, J. (2002). Analysis of penalties taken in shoot-outs. *International Journal of Performance Analysis,* August, 2 (1):55-72(18).

Hyman, R. (1953). Stimulus information as a determinant of reaction time. *Journal of Experimental Psychology,* 45: 188-196.

Ibanez, S.J.; Sampaio, J.; Saenz-Lopez, P.; Gimenez, J. & Janeira, M.A. (2003). Game statistitics discriminating the final outcome of Junior world Basketball Championships matches (Portugal 1999). *Journal of Human Movement Studies,* (45):001-019.

Iglesias, D.; Moreno, M.P.; Santos-Rosa, F.J.; Cervelló, E.M., & Del Villar, F. (2005). Cognitive expertise in sport: Relationships between procedural knowledge, experience and performance in youth basketball. *Journal of Human Movement Studies*, 49:065-076.

Janelle, C.C. & Hillman, C.H. (2003). Expert performance in sport: Current perspectives and critical issues. In J.L. Starkes & K.A. Ericsson (eds.) *Expert performance in sports – Advances in research on sport expertise,* pp.19-48. Champaign, IL: Human Kinetics.

Jenkins, R.E., Morgan, L. & O'Donoghue, P. (2007). A case study into the effectiveness of computerised match analysis and motivational videos within the coaching of a league netball team. *International Journal of Performance Analysis in Sport,* 7(2): 59-80(22)

Jones, P.D.; James, N. & Mellalieu, D. (2004). Possession as a performance indicator in soccer. *International Journal of Performance Analysis,* Augustus, 4(1):98-102.

Kioumourtzoglou, E.; Michalopoulou, M.; Kourtessis, G.T. & Kourtessis, T. (1998). Cognitive abilities supporting expertise in team sports. *Coaching and Sport Science Journal,* 3(1):30-36.

Knudson, D. & Kluka, D.A. (1997). The impact of vision and vision training on sport performance. *Journal of Physical Education, Recreation and Dance,* 68(4): 17-24

Laird, P. & Lorimer, R. (2004). An examination of try scoring in rugby union: a review of international rugby statistics. *International Journal of Performance Analysis in Sport,* August, 4(1): 72-80(9).

Laird, P & Sutherland, P. (2003). Penalty Corners in Field Hockey: A guide to success. *International Journal of Performance Analysis in Sport,* April, 3(1):19-26(8).

Launder, A. (2003). Revisit 'game sense'. *Sports Coach,* 26(1): 32-37.

Leviton, R. (1992). *Seven steps to better vision*. New York: East West/Natural Health Books.

Ludeke, A. & Ferreira, J.T. (2003). The difference in visual skills between professional versus non-professional rugby players. *The South African Optometrist,* December, 62(4): 150-158.

Lyons, K. (2002), Performance Analysis: Interpretating data, *FHS*, July, 16:22-23.

Magill, R.A. (2003). Motor learning and control – Concepts and applications (7th ed). Boston, MA: McGraw Hill.

Mascarenhas, D.R.D.; Collins, D. & Mortimer, P. (2005). The accuracy, agreement and coherence of decision-making in rugby union officials. *Journal of Sport Behaviour,* September, 28(3):253-271.

McPherson, S.L. (1999). Expert-novice differences in performance skills and problem representations of youth and adults during tennis competition. *Research Quarterly for Exercise and Sport,* September, 70 (3):233-251.

McPherson, S.L. & French, K.E. (1991). Changes in cognitive strategies and motor skill in tennis. *Journal of Sport & Exercise Psychology*, 13(1): 26-41.

McPherson, S.L. & Kernodle, M.W. (2003). In J.L. Starkes & K.A. Ericsson (eds.) *Expert performance in sports – Advances in research on sport expertise,* pp.137-168. Champaign, IL: Human Kinetics.

McMorris, T. (1997). Performance of soccer layer on tests of field dependence/independence and soccer specific decision-making tests. *Perceptual and Motor Skills*, 85(2):467-476.

McMorris, T. (1999) Cognitive development and the acquisition of decision-making skills. *International Journal of Sport Psychology*, 30: 151-172.

McMorris, T. & Graydon, J. (1997). The effect of exercise on cognitive performance in soccer-specific tests. *Journal of Sports Sciences*, 15(5):459-468.

Melcher, M.H. & Lund, D.R. (1992). Sports vision and the high school student athlete. *Journal of the American Optometric Association,* 62(7):466-474.

Mendes, L. & Tavares, F. (2003). The defensive dimension in basketball analysis of the cinematic pattern of the defensive slide, the declarative knowledge and technical and tactical structures. *International Journal of Performance Analysis in Sport,* April, 3 (1): 27-99(7).

Michalopoulou, M.; Papadimitriou, K.; Lignos, N.; Taxildaris, K. & Antoniou, P. (2005). Computer analysis of the technical and tactical effectiveness in Greek Beach Volleyball. *International Journal of Performance Analysis in Sport*, June, 5(1):41-50(10).

Mulligan, D.; Dobson, M. & McCracken, J. (2005).“The use of video game technology for investigating perceptual and cognitive awareness in sports”. [http://www.gamesconference.org/digra2005]. Retrieved 30 September, 2005.

O’Donoghue, P. (2005). Normative profiles of Sports Performance. *International Journal Performance Analysis in Sport*, June, 5(1):104-119(16).

Papanikolaou, Z.K. (2000). The Athletic Intelligence. *International Journal of Physical Education*, 1:24-28.

Paull, G. & Glencross, D. (1997). Expert perception and decision-making in baseball. *International Journal of Sport Psychology*, 28 (1):35-56.

Penrose, J.M.T. & Roach, N.K. (1995). Decision making and advanced cue utilisation by cricket batsmen. *Journal of Human Movement Studies*, 29:199-218.

Prim, S.; van Rooyen, M. & Lambert, M. (2006). A comparison of performance indicators between the four South African teams and the winners of the 2005 Super 12 Ruby competition. What separates top from bottom? *International Journal Performance Analysis in Sport,* November, 6 (2):126-133(8).

Rendell, M. & Morgan, S.W. (2005). Skill and role-specific differences in eye movement behaviour between goal keepers and field hockey players in field hockey. *International Journal of Performance Analysis in Sport,* December, 5 (3): 163-167.

Ripoll, H. & Benguigui, N. (1999). Emergence of expertise in ball sports during child development. *International Journal of Sport Psychology*, 30: 235-245.

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

Ross.J. (2001). “Level 3 Coaching Paper (Decision-Making and Coaching)”. [http://aru.rugby.com.au/verve/_resources/J.Ross-_Decision_Making_2001.pdf]. Retrieved 13 July, 2005.

Sampaio, J. & Janeira, M. (2003). Statistical analyses of basketball team performance understaning teams wins and losses according to a different index of ball possession. *International Journal of Performance Analysis in Sport,* April, 3(1):40-49(10).

Scott, D.; Scott, L.M. & Howe, B.L. (1998). Training anticipation for intermediate tennis players. *Behavior Modification*, 22 (3):243-262.

Seyers, M.G.L. & Washington-King, J. (2005). Characteristics of effective ball carries in Super 12 rugby. *International Journal of Performance Analysis in Sport*, December, 5 (3):92-106.

Shaw, D., Gorely, T. & Corban, R. (2005). *Sport and Exercise Psychology*. Oxford: BIOS Scientific Publishers.

Smith, L. (n.d.). "Quick Thinking Part 2." *Spontaneity isn't random.* [http://www.irb.com/mm/document/training/0/051213quickthinking_441.pdf]. Retrieved March 6, 2006.

Smith, R. (1994). Running Patterns and Body Position to Improve Decision-making in Players. *Sports Coach*, January – March: 20-21.

Smith, R.G. (1984). Decision-making in high level sport. *Sports Coach*, 8(1):24-30.

Starkes, J.L. & Ericsson, K.A. (2003). *Expert performance in Sports.* Champaign, IL: Human Kinetics.

Starkes, J.L. & Lindley, S. (1994). Can we hasten expertise by video simulations? *Quest*, 46:211-222.

Tavares, F. (1997). Decision making in basketball: a computer assisted video-test for evaluation. In M. Hughes (Ed.), *Notational Analysis of Sport I & II* , pp213-219. Cardiff: University of Wales Institute of Sport.

Taylor, J.B.; Mellalieu, S.D.& James, N. (2005). A comparison of individual and unit tactical behaviour and team strategy in professional soccer. *International Journal of Performance Analysis in Sport,* November, 5(2):87-101(15).

Tenenbaum, G. & Bar-Eli, M. (1993). Decision making in sport: A cognitive perspective. In, Singer, R.N. (ed.), al., *Handbook of research on sport psychology* (pp. 171-192). New York: Macmillan.

Thomas, K.T. (1994). The development of sport expertise: From Leeds to MVP legend. *Quest*, 46:19–210.

Thomas, J.R. & Nelson, J.K. (2001). *In Research methods in physical activity.* Champaign: Human Kinetics.

Turner, A.P & Martinek, T.J. (1999). An Investigation into teaching games for Understanding: Effects on Skill, Knowledge, and Game Play. *Research Quarterly for Exercise in Sport*, 70: 286-296.

Turner, A. & Martinek, T.J. (1995). Teaching for understanding: A model for improving decision-making during game play. *Quest*, 47 (1):44-63.

Tyler, P. (n.d.). "Games and drills for improving vision for rugby." [http://www.rugbyns.ns.ca/asp/coaching/docs/New%20Resources/Games%20Drills%20For%20Improving%20Vision.pdf]. Retrieved 11 July, 2005.

University of Michigan Virtual Reality Laboratory at the College of Engineering, (2004). "The Virtual Football Trainer." [www-rl.umich.edu/project/football/]. Retrieved 22 September, 2005.

Vaeyens, R.; Lenoir, M.; Williams, A.M. & Philippaerts, R.M. (2007). Mechanisms Underpinning Successful Decision Making in Skilled Youth Soccer Players: An Analysis of Visual Search Behaviors. *Journal of Motor Behavior*, September, 39(5): 395-408.

Vickers, J.N.; Livingston, L.F.; Umeris-Bohners, S. & Holden, D. (1999). Decision training: The effects of complex instruction, variable practice and reduced delayed feedback on the acquisition and transfer of a motor skill. *Journal of Sports Sciences*, 17:357-367.

Villepreux, P. (1993). "Decision making in rugby." [http://www.rugbycoach.com/club/french/decision.htm]. Retrieved 1 February 2005.

Venter, S.C. & Ferreira, J.T. (2004). A Comparison of visual skills of high school rugby players from two different age groups. *The South African Optometrist,* March, 63(1): 19-29.

Williams, A., Davids, K., Burwitz, L. & Williams, J. (1994). Visual search strategies in experienced and non-experienced soccer players. *Research Quarterly for Exercise and Sport*, 65(2): 127-135.

Williams, A.M & Davids, K. (1998). Visual search strategy, selective attention, and expertise in soccer. *Research Quarterly for Exercise and Sport*, 69(2): 111 – 128.

Williams, A.M., Davids, K. & Williams, J.G. (1999). *Visual perception and action in sport.* London: Taylor & Francis.

Williams, AM & Grant, A. (1999) Training perceptual skill in sport. *International Journal of Sport Psychology*, 30: 194-220.

Wilson, C. (2002). A need for performance analysis? *FHS*, July, 16:8-9.

Winkler, W. (2001). Motor skills and cognitive training for junior soccer players. *International Journal of Performance Analysis in Sport*, July, 1(1): 91-105(15).

Appendix A

Reliability of the Decision Making Test Instrument

Correct Answer	Answer	Post-Test Accuracy of Decision Making		Reliability Test Accuracy of Decision Making	
		N	**Percentage**	**N**	**Percentage**
		Clip 1			
3	3	34	89.50%	35	92.10%
	4	4	10.50%	3	7.90%
		Clip 2			
	2			2	5.30%
3	3	25	65.80%	22	57.90%
	4	13	34.20%	14	36.80%
		Clip 3			
	3	7	18.40%	11	28.90%
4	4	11	28.90%	10	26.30%
	5	20	52.60%	17	44.70%
		Clip 4			
3	3	16	42.10%	10	26.30%
	4	16	42.10%	23	60.50%
	5	6	15.80%	5	13.20%
		Clip 5			
3	2	6	15.80%	5	13.20%
	3	31	81.60%	32	84.20%
	4	1	2.60%	1	2.60%
		Clip 6			
	0			1	2.60%
	2	2	5.30%	1	2.60%
3	3	34	89.50%	35	92.10%
	4	2	5.30%	1	2.60%
		Clip 7			
3	3	26	68.40%	23	60.50%
	4	9	23.70%	12	31.60%
	5	3	7.90%	3	7.90%
		Clip 8			
2	2	13	34.20%	10	26.30%
	3	23	60.50%	21	55.30%
	4	2	5.30%	6	15.80%
	5			1	2.60%
		Clip 9			
	2	26	68.40%	25	65.80%
3	3	11	28.00%	12	31.60%
	4	1	2.60%	1	2.60%
		Clip 10			
	2	2	5.30%	1	2.60%
3	3	26	68.40%	27	71.10%
	4	5	13.20%	7	18.40%
	5	5	13.20%	3	7.90%

Correct Answer	Answer	Post-Test Accuracy of Decision Making		Reliability Test Accuracy of Decision Making	
		N	Percentage	N	Percentage
		Clip 11			
	3	24	63.20%	24	63.20%
4	4	7	18.40%	10	26.30%
	5	7	18.40%	4	10.50%
		Clip 12			
2	2	28	73.70%	23	60.50%
	3	8	21.10%	13	34.20%
	4	2	5.30%	2	5.30%
		Clip 13			
3	3	14	36.80%	15	39.50%
	4	24	63.20%	23	60.50%
		Clip 14			
3	3	23	60.50%	16	42.10%
	4	15	39.50%	22	57.90%
		Clip 15			
	3	18	47.40%	22	57.90%
	4	14	36.80%	11	28.90%
5	5	6	15.80%	5	13.20%
		Clip 16			
	3	15	39.50%	15	39.50%
	4	8	21.10%	13	34.20%
5	5	15	39.50%	10	26.30%
		Clip 17			
	2	1	2.60%	2	5.30%
3	3	30	78.90%	34	89.50%
	4	6	15.80%	2	5.30%
	5	1	2.60%		
		Clip 18			
	3	28	73.70%	29	76.30%
	4	6	15.80%	5	13.20%
5	5	4	10.50%	4	10.50%
		Clip 19			
	2	1	2.60%	2	5.30%
3	3	21	55.30%	24	63.20%
	4	13	34.20%	10	26.30%
	5	3	7.90%	2	5.30%
		Clip 20			
3	3	3	7.90%	8	21.10%
	4	35	92.10%	30	78.90%
		Clip 21			
2	2	35	92.10%	37	97.40%
	3	2	5.30%		
	4	1	2.60%	1	2.60%
		Clip 22			
3	3	22	57.90%	23	60.50%
	4	16	42.10%	14	36.80%
	5			1	2.60%

Correct Answer	Answer	Post-Test Accuracy of Decision Making		Reliability Test Accuracy of Decision Making	
		N	Percentage	N	Percentage
Clip 23					
	2	11	28.90%	10	26.30%
	3	15	39.50%	18	47.40%
4	4	12	31.60%	10	26.30%
Clip 24					
	3	2	5.30%	1	2.60%
	4	3	7.90%	4	10.50%
5	5	33	86.80%	33	86.80%
Clip 25					
	2	1	2.60%	1	2.60%
	3	10	26.30%	7	18.40%
	4	14	36.80%	13	34.20%
5	5	13	34.20%	17	44.70%

Appendix B

Sports Vision Testing Battery

Vertical Saccades

1. Sit comfortably on the chair provided. You may place your hands/arms in any comfortable position.

2. Place your chin on the chin rest. This is designed to keep your head still during the tests.

3. When the test administrator signals "Ready? Go!" the timer will be started.

    - You should immediately begin reading aloud the pairs of letters, first the top letter, then the bottom letter, then back to the next top letter and then down to the next bottom letter, and so forth.

    - Keep reading aloud until you have read out all of the pairs of letters as quickly as possible.

4. When you read aloud the last pair, the test administrator will stop the timer.

Scoring:

Your score is the number of seconds it takes you to complete reading aloud all of the pairs on the chart. If you have made any errors, a two-second penalty will be added to your time for each error you make.

Note:

- *You should read out the pairs as fast and as accurately as you can.*
- *Take the test in your home language (you will be faster).*
- *If you make a mistake in reading out the pairs, the test administrator will mark the error on the score sheet, but not stop you.*
- *If you make a mistake in reading out the pairs, and discover that mistake, you can correct your error. Although it will take you a bit of time, you will not be charged with an error.*

Horizontal Saccades

1. Sit comfortably on the chair provided. You may place your hands/arms in any comfortable position.

2. Place your chin on the chin rest. This is designed to keep your head still during the tests.

3. When the test administrator signals "Ready? Go!" the timer will be started.

    - You should immediately begin reading aloud the pairs of letters, first the letter on the left, then the letter on the right, then back to the next letter on the left and then to the next letter on the right, and so forth.

    - Keep reading aloud until you have read out all of the pairs of letters as quickly as possible.

4. When you read aloud the last pair, the test administrator will stop the timer.

Scoring:

The number of seconds it takes you to complete reading aloud all of the pairs on the chart. If you have made any errors, a two-second penalty will be added to your time for each error you make.

Note:

- *You should read out the pairs as fast and as accurately as you can.*
- *Take the test in your home language (to increase your speed).*
- *If you make a mistake in reading out the pairs, the test administrator will mark the error on the score sheet, but not stop you.*
- *If you make a mistake in reading out the pairs, and discover that mistake, you can correct your error. Although it will take you a bit of time, you will not be charged with an error.*

Near-Far Saccades

1. Sit comfortably on the chair provided. You may place your hands/arms in any comfortable position, but you may not use them during the test to help you keep track of your place on either of the charts.

2. When the test administrator signals "Ready? Go!" the timer will be started.

    - You should immediately begin reading aloud the pairs of letters, first the letter closest to you, then the letter that is furthest away, then back to the next closest letter and then to the furthest letter, and so forth.

    - Keep reading aloud until you have read out all of the pairs of letters as quickly as possible.

3. When you read aloud the last pair, the test administrator will stop the timer.

Scoring:

Your score is the number of seconds it takes you to complete reading aloud all of the pairs on the chart. If you have made any errors, a two-second penalty will be added to your time for each error you make.

Note:

- *You should read out the pairs as fast and as accurately as you can.*
- *Take the test in your home language (to increase your speed).*
- *If you make a mistake in reading out the pairs, the test administrator will mark the error on the score sheet, but not stop you.*
- *If you make a mistake in reading out the pairs, and discover that mistake, you can correct your error. Although it will take you a bit of time, you will not be charged with an error.*

Pursuit Tracking

1. Sit comfortably on the chair provided. You may place your hands/arms in any comfortable position.

2. When the test administrator signals "Ready? Go!" the timer will be started.

- You should immediately begin reading aloud the pairs of letters, first the letter closest to you, then the letter furthest away, then back to the next closest letter and then to the next furthest letter, and so forth.

- Keep reading aloud until you have read out all of the pairs of letters as quickly as possible.

3. When you read aloud the last pair, the test administrator will stop the timer.

Scoring:

Your score is the number of seconds it takes you to complete reading aloud all of the pairs on the chart. If you have made any errors, a two-second penalty will be added to your time for each error you make.

Note:

- *You should read out the pairs as fast and as accurately as you can.*
- *Take the test in your home language (to increase your speed).*
- *If you make a mistake in reading out the pairs, the test administrator will mark the error on the score sheet, but not stop you.*
- *If you make a mistake in reading out the pairs, and discover that mistake, you can correct your error. Although it will take you a bit of time, you will not be charged with an error.*

Static Visual Acuity

1. Sit comfortably on the chair that has been placed on the mark 20 feet from the Snellen chart.

2. Cover your left eye with the paddle provided, then try to read aloud each letter on the top line of the chart.

    - Continue to read each letter in each line until you either read the bottom line on the chart, or find it impossible to see clearly each of the letters on a given line.

3. When you read aloud the last pair, the test administrator will hang a new Snellen chart on the wall, and then repeat the testing procedure for your left eye. When you have completed the test with your left eye, a third chart will be put on the wall and you will attempt the test with both eyes open.

Scoring:

Your score is the last line on which you were able to read every letter correctly.

Dynamic Visual Acuity

1. Stand in front of the disc rotator that has been placed on the table. You will notice that there is a cover on the rotator to prevent you from seeing the rotating disc.

2. Take the pointer in your preferred hand and prepare yourself to search for the letters of the alphabet in sequence. Your task will be to tap each letter with the pointer as you pronounce it. This task will be challenging because the letters of the alphabet are distributed randomly on the disc and the disc is rotating.

3. When the cover is lifted, begin to tap out the alphabet as quickly as you can.

Scoring:

Your score will be the number of letters you can find within one minute of the viewing time.

Note:

- *You should try to find and tap out/read aloud the letters as fast as you can.*
- *Do not tap the letters with too much force (you will damage the rotator).*
- *Take the test in your home language (to increase your speed).*

Coincident Timing

1. Stand at the near end of the Bassin Timer runway, directly facing the 3m runway of lights.
2. The runway consists of a line of lights that will simulate the pathway of a ball coming toward you.
3. Place one of your fingers (you choose), directly over but not on the white button. The test administrator will then start the test. A yellow warning light will appear at the far end of the runway to alert you to the test. Then the red lights will come on then off in a sequence from the far end of the runway to the near end, to simulate the approach of a ball.
4. Your task is to press the white button at the near end of the runway when you anticipate that the light will arrive at that button.

Scoring:

Your score is recorded as the time you deviate from perfection, either early or late, for each of your trials.

Visual Memory

1. Your will be given a matrix of numbers from 00 to 99 in a scrambled order. The matrix will be placed face down on the table.
2. At the signal "go", turn over the matrix and begin to mark through the numbers in sequence, starting with 00, then 01, 02, etc., until you hear the "Stop" signal.

Scoring:

Your score will be the number you were able to reach in the 2-minute period.

Note:

- *You should try to find and mark out the numbers in sequence as fast as you can.*

Peripheral Awareness
(left and right)

1. Sit comfortably on the chair that is facing the horizontal perimeter.

2. Place your chin on left chin rest and gently cover your left eye with the paddle provided. Focus the vision of your right eye on the white dot in the centre of the perimeter (the dot is directly in front of you).

3. The test administrator will begin to slowly bring in a small coloured paddle from your right. Keep your vision focused on the white dot, but when you can detect the colour of the paddle, tell the test administrator to “stop” and announce what colour you have “seen” in your peripheral vision.

   - The test administrator may test you several times with several different colours from your right side. Make sure you wait until you see the colour before you call out “stop.” You will see motion before you see colour, so try not to call out “stop” too early.

   - The procedure is then repeated for your left eye, with you chin resting on the right chin rest instead.

Scoring:

Your score will be the º (degrees) on the 180º perimeter at which you could correctly detect the colour of the paddle when it is brought in from your right, and when it is brought in from your left.

If several paddles of different colours are used, then the ◦ mark for each colour will be recorded separately.

Appendix C

Example of Weekly Rugby Training Programme

<u>RPC PROGRAMME</u>

WEEK 7 (06)

6 March - 12 March 2006

"The Harder you Work, the Harder it is to Surrender"

MONDAY (6)	TUESDAY (7)	WEDNESDAY (8)	THURSDAY (9)	FRIDAY (10)	SATURDAY (11)	SUNDAY (12)
08h00 **Group A:** Virgin **Weight Training (12)** SS **(BL)**	**08h30** **FORWARDS** **Vision (6)** WA **(RED)**	**08h00** **Group B:** Virgin **Weight Training (13)** SS **(WP)**	**08h30** **BACKS** **Vision (6)** WA **(GREEN)**	**08h00** **Group C:** Virgin **Weight Training (14)** SS **(BP)**	**09h00** Match Preparation Warm-up	**<u>REST</u>**
09h00 **Group B:** Virgin **Weight Training (12)** SS **(BL)**	**09h30** **SQUAD: NNK Rugby** **Rugby Fitness** SS **(RED)**	**09h00** **Group C:** Virgin **Weight Training (13)** SS **(WP)**	**09h30** **SQUAD: NNK Rugby** **Rugby Fitness** SS **(GREEN)**	**09h00** **Group A:** Virgin **Weight Training (14)** SS **(BP)**	**10h00** **Match:** RPC x2 NNK Rugby **Team NAVY** **vs** **Team RED**	
10h00 **Group C:** Virgin **Weight Training (12)** SS **(BL)**	**10h30** **Forwards: Rugby - AZ (RED)** **Backs: Wrestling - WG (ANY)**	**10h00** **Group A:** Virgin **Weight Training (13)** SS **(WP)**	**11h15** **Backs:** Rugby - AZ **(GREEN)** **Forwards:** Karate - BL **(Leuko)**	**10h00** **Group B:** Virgin **Weight Training (14)** SS **(BP)**		
10h30 **Group A:** Team Room **Statistics** BA **(RT)**	**12h15** **Group(1st years):** Team Room **Psychology (4)** JP **(RT)**	**12H15** **Squad: On Field** **Laws of the Game** FB **(NAVY)**	**12h30** **Backs:** Pool Session (TA & GV) **13h00:** **Forwards:** Pool Session (TA & GV)			
13h00: Lunch	**13h00: Lunch**	**13h00: Lunch**	**13h00: Lunch**			
14h30 **Squad: NNK Rugby Session** AZ **(GREEN)**	**14h30** **Squad: NNK Rugby Session** AZ **(RED)**	**14h30** **Squad: NNK Rugby Session** AZ **(NAVY)**	**REST**	**REST**		

Appendix D

Category set for the Analysis of Rugby games

Level 1. Team	Team A	Opponents			
Level 2. Type of play	Scrum	Line-outs	Kick-offs	Penalties	Tries
Level 3. Results of play	Retained ball	Lost ball			
Level 4. Reasons	Good skill or tactical performance	Poor skill or tactical performance	Turnover due to opponents good play		
Level 5. Where event happened	Opposition Half	Opposition 22m	Own Half	Own 22m	

Appendix E

Sample Visual Skills Training Session 1

Warm-up

- Follow your thumbs – work in a group of two.
- Also from the side if the player stands behind you.

Dynamic Visual Acuity – Ball Toss *different sizes and colours balls x 25*

- Work with different colours and sizes ball.
- Work in a group of two.
- Stand with your back towards your partner, about 2m from each other.
- The player can call left and right and passing the ball.
- The worker still has to identify the colour of the ball.
- Work on normal passes and bounce balls.

Basketball – Coordination *14 tennisballs/14 basketballs*

- Work in a group of two.
- Each person must have two tennis balls or basketballs.
- Bounce ball on the sides of your body.
- The direction of the bounce has to be forward and to the back.
- Bounce both hands in the same direction.
- When controlled bounce ball with right hand in forward direction and with left hand in backward direction.
- Bounce ball in front of your body with both hands and in different directions.
- Fast feet.
- Partner can call “in front” or “side” and worker must immediately change direction.

Peripheral Vision *rugby balls/tennis balls*

- Work in a group of four.
- Form a 90 degree triangle.
- Focus forward, do not move head only eyes.
- Ball can be received from either side.

Peripheral Vision *buckets & tennis balls*

- Work in a group of three.
- Receive ball from left and pass in bucket on right while focusing forward.
- Do the same on other side.
- Place more buckets on different metres.
- Partner in front can call out which bucket the worker has to throw to, nr one or two when receiving the ball.
- Ball can be received from either side.

Mind game *rugby balls*

- Groups of five.
- Throwing balls and get instructions at the same time.
- Number people.
- Give instructions, for example: Throw the ball to number two and run to number three.

Two on One game *rugby balls/tennis balls*

- More speed – stopwatch.
- No falls.
- More defenders.
- Only backwards passing.

Appendix F

Sample Visual Skills Training Session 12

Warm-up

rugby balls

- Figure eight.
- Close eyes while doing.
- One player with one ball.
- Walking figure eight.
- Remember to enter the figure eight in front of the leg and not from the back.
- Competition can be 30s; how many the person can do without dropping the ball.
- Running Figure eight.

Rugby – Hand-eye-coordination

14 tennisballs/14 basketballs

- Triangle.
- One Player.
- Stand with feet shoulder length apart.
- If possible, stand above a line, for example, on a tennis court, where the line and the player's feet form a triangle.
- Bounce ball in right hand.
- Move ball in left hand to right hand while the first ball is bounced.
- Think about passing balls in a circle.
- When it is done smoothly, try to do it faster.
- Execute it faster.
- While doing a fast feet movement.

Peripheral Vision

rugby balls/tennis balls

- Work in a group of twelve.
- Four workers, eight throwers.
- Form a 90 degree triangle, put four triangles together.
- Focus forward, don't move head only the eyes.
- Ball can be received from either side.
- Work with colour cards.
- Name colour cards correctly.
- When receive a pass, move on to a next position.
- Work with arrow signs as well.

Hand-eye-coordination – Keep ball alive

14 tennisballs/14 basketballs

- One person with two balls.
- Start with balls in both hands.
- Only work with one hand.
- Throw ball in right hand up – high enough, when released throw ball two up.
- From now on catch and throw with the same hand.

- Form a rhythm and with big circles.
- Use three balls.

Decision-making game - Defensive

rugbyballs

- Work in groups of nine or more.
- Form two lines of four each.
- Face each other and stand approximately10m apart.
- One person stands in the middle to form a triangle.
- Player C throws the ball up.
- Player A & B (line one), only then run a split lead.
- Player C can decide to pass the ball to either player A or B.
- When player A receive ball, pass ball to player B, a square pass.
- Player C needs to intercept the square pass.
- If player C intercepts - pass the ball to opposite line to start again.
- Player C moves to outside and then to the back of the opposite row.
- Add colour cards.

Visual Memory

- Play in a group of two.
- Use number cards.
- Mix the cards.
- Pack it in a line facing downwards.
- Quickly show the worker the order of the cards.
- The worker needs to put it in the correct order.
- Each player needs to do it five times.

Designer GAME

Dribblers and robbers *rugby balls/tennis balls*

Appendix G

Visual Skills Planning

	Visual Acuity	Eye hand Coordination	Peripheral vision	Coincident Timing	Visual Memory	Decision making game	Skill & Decision making
Lesson 1	x	x	x	x			
Lesson 2	x	x	x	x	x		
Lesson 3	x	x	x	x	x	x	
Lesson 4	x	x	x	x	x	x	
Lesson 5	x	x	x	x	x	x	
Lesson 6	x	x	x	x	x	x	x
Lesson 7	x	x	x	x	x	x	x
Lesson 8	x	x	x	x	x	x	x
Lesson 9	x	x	x	x	x	x	x
Lesson 10	x	x	x	x	x	x	x
Lesson 11	x	x	x	x	x	x	x
Lesson 12	x	x	x	x	x	x	x

Appendix H

Visual Skills Frequency Tables

Group 1	**Needs work**				**Satisfactory**				**Good**		**Missing**		
	N	**Pre**	**Post**	**N**	**N**	**Pre**	**Post**	**N**	**N**	**Pre**	**Post**	**N**	**Post**
Static Visual Acuity	5	12%	22%	9	11	27%	17%	7	25	61%	49%	20	12%
Dynamic Visual Acuity	17	42%	29%	12	16	39%	37%	15	8	20%	22%	9	12%
Peripheral Awareness Left	11	27%	2%	9	8	20%	20%	11	22	54%	66%	16	12%
Peripheral Awareness Right	7	17%	12%	5	10	24%	32%	13	24	59%	44%	18	12%
Pursuits	11	27%	20%	8	16	39%	29%	12	14	34%	42%	16	12%
Vertical Saccades	15	37%	10%	4	14	34%	27%	11	12	29%	51%	21	12%
Horisontal Saccades	16	39%	37%	15	10	24%	17%	7	15	37%	34%	8	12%
Near-far Saccades	26	63%	27%	11	9	22%	29%	12	6	15%	32%	13	12%
Coincident Timing	8	20%	5%	2	26	63%	73%	30	7	17%	10%	4	12%
Visual Memory	18	44%	17%	7	7	17%	12%	5	16	39%	59%	24	12%

Group 2	**Needs work**				**Satisfactory**				**Good**		**Missing**		
	N	**Pre**	**Post**	**N**	**N**	**Pre**	**Post**	**N**	**N**	**Pre**	**Post**	**N**	**Post**
Static Visual Acuity	18	54%	24%	12	13	30%	20%	14	15	15%	30%	8	26%
Dynamic Visual Acuity	25	52%	26%	4	14	35%	30%	7	7	13%	17%	23	26%
Peripheral Awareness Left	24	61%	9%	4	16	26%	15%	3	6	13%	50%	27	26%
Peripheral Awareness Right	28	39%	9%	17	12	28%	7%	6	6	33%	59%	11	26%
Pursuits	18	39%	37%	14	13	35%	13%	7	15	26%	24%	13	26%
Vertical Saccades	18	39%	30%	19	16	28%	15%	5	12	33%	28%	10	26%
Horisontal Saccades	32	70%	41%	19	4	9%	11%	5	10	22%	22%	10	26%
Near-far Saccades	26	57%	33%	15	13	28%	22%	10	7	15%	20%	9	26%
Coincident Timing	10	22%	24%	11	35	76%	46%	21	1	2%	4%	2	26%
Visual Memory	24	52%	35%	16	10	22%	17%	8	12	26%	22%	10	26%