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Developing game awareness, perception and decision-making in elite youth footballers.

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A thesis submitted in partial fulfilment
of requirements for the degree of
Masters of Education (Research)

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Abstract

Developing game awareness, perception and decision-making in elite youth footballers.

In football, elite players appear to have more time and space, understand the pattern of the game, make better decisions with the ball and be one step ahead of their opponents. Some players are anecdotally believed to 'just have it'.

This study examined the process of perception-decision-execution during skill acquisition within football and whether training focussed on cognition and perception leads to players' decision-making being improved. There appears to be a gap in both the research and application in the sporting context as to the role and trainability of decision-making in football and whether greater perception of the in-game environment contributes to better decision-making.

The aim of the study was to examine the effects of multi-task and cognitive effort training during football practice and to determine the impact of these methods on perception and decision-making regarding a player's first touch in the match environment. The study involved an experimental design using a control trial during the intervention. Players from two teams (N=31, age M=14.18, SD=0.55), competing in the NSW National Youth Premier League (NYPL) were divided into control and intervention groups and completed testing at three time points (pre-, post-intervention and retention)

A training intervention was conducted replacing the 20 minute traditional passing practice component of the training. The intervention consisted of cognitive load exercises based on first touch ball manipulation and movements commonly found in football. The effectiveness of the training intervention was assessed via three methods; a video-based decision-making test using 20 video clips with players depicting their first touch, a questionnaire self-assessing decision-making and expert analysis of individuals' game performance from footage of games.

Results indicate that the altered training environment was equally effective to traditional passing practices in all three measures used in the study. There was a significant difference in the video-based testing ($p < .01$), for both the control and intervention groups between pre-test (M=7.196) and post-test (M=10.714) and between pre-test (M=7.196) and retention test (M=10.750) supporting previous studies that on field training positively influences decision-making in video-based tests. The

questionnaire revealed players self-assessed their decision-making ability at a constant level across both the control and intervention groups. Game performance in the match environment indicated players made less poor decisions leading to losing possession, but did not improve decision-making to create more scoring chances.

The impact of the altered training environment on players across the three measures are discussed along with the implications of the results for the development of decision-making in youth football. Recommendations are made for the scope and focus of future research into training and testing decision-making through cognitive load training.

Acknowledgements

To my wife, Laura, thank you for the love, support and encouragement that enabled me to undertake this thesis and see it through to completion, particularly given we have a baby just weeks away!

To my supervisor, Donna O'Connor, thank you for everything. From encouraging me to write this thesis in the first place, to your constant support, encouragement and patience throughout the project I am immensely grateful. You have kept me on track during a very challenging year and your knowledge and commitment are inspiring.

To my Mum, Dad and family, your constant support and encouragement to follow my dreams gives me so much strength and drive to succeed. Thank you for everything.

To all my friends, particularly those I have not seen nearly enough over the past year, thank you for your support and I very much look forward to some long overdue catch-ups.

To Spencer Prior and Joe Haywood; colleagues, mentors and most importantly friends who have always been there for me both throughout this project and over the past few years. Thankyou.

Finally, to the North Shore Mariners and particularly Wayne O'Sullivan, thank you for your support of this project and allowing me access to your teams and coaches. I hope this thesis helps in some way to help advance your program.

Contents

CHAPTER ONE

Introduction

Development of the topic

When watching football, elite players appear to have better 'game intelligence' characterised by having more time, a greater understanding of their surrounds and the ability to make better decisions along with the skill set to execute those decisions. Some players are anecdotally believed to 'just have it'. Perception (seeing, hearing and anticipating), decision (selecting an action) and execution (performing that action) are key facets of the sport that are tightly interwoven and lead to skilled performance. This thesis examines the process of perception-decision-execution during skill acquisition within the sport of football and examines whether alternative training methods focussing specifically on cognitive load training to improve perception leads to players' first touch decision-making being improved.

The development of sound decision-making skills has been the focus of a number of studies both in football (Gabbett, Carius, & Mulvey, 2008; Marques, 2010; Vaeyens, Lenoir, Williams, Mazyn, & Philippaerts, 2007) and in other sports (Bruce, Farrow, Raynor, & May, 2009; Lorains, 2013; Lorains, Ball, & MacMahon, 2013), as it is widely regarded as one of the key attributes of expert performers, but remains a contentious area given the lack of evidence as to how best to develop it. Furthermore, superior perceptual, anticipatory and decision-making skills preceding superior skill execution have been reported to be key components of expert performance (Baker, Cote, & Abernethy, 2003; Luhtanen, Blomqvist, & Vanttinen, 2004; Memmert, Simons, & Grimme, 2009).

At the elite level, players generally have minimal touches and time on the ball each time they have possession (Carling, 2010; FIFA technical study, 2008; Bradley et al., 2013). In a study of 30 *Ligue 1* matches in France, players averaged two touches per possession and 1.1 seconds per individual player possession (Carling, 2010). A similar study in England across the top three leagues, the Premier League, 2.5 touches per possession, Championship, 2.2 touches per possession, and League One, 1.8 touches per possession with central defenders averaging just 1.4 touches per possession in League One (Bradley et al., 2013). Consequently, quick and accurate decisions when first receiving the ball are vital to elite level performance.

Football Federation Australia (FFA) has classified the stages of player development into four areas according to age; the discovery phase (ages 5-9), skill acquisition phase (9-13), game training phase (13-17) and performance phase (17+). The game training phase is intended to develop players' tactical awareness and therefore decision-making is of key importance (FFA, 2013). Technical study groups have identified weaknesses in Australian players as being technically and tactically poor (FFA, 2013). The nature of football, a complex and skilled sport with a need to integrate sensory input to be successful, means that the ideal circuitry in the brain has great speed and flexibility to deal with the changing obstacles to performance (Clark et al., 2015).

The FFA National Curriculum (2013) and Cross (2013) discuss the importance of a largely athlete-centred, holistic approach to training whereby activities reflect the game and drills are not done in an isolated fashion. This reflects the suggestions of important studies (Ford, Yates, & Williams, 2010; Cushion, Ford, & Williams, 2012) as to the effectiveness of different training types. Playing Form (e.g. small-sided games, possession based games) replicates match-like activities and situations in order to not only develop execution of motor skills but also perceptual-cognitive skills (Williams & Ward, 2007). It is more likely to lead to greater retention and transfer to the match environment. Ford et al. (2010) highlight that replication of the interaction between perception, cognition and motor skills is difficult in practice activities that involve no opponents or limited opposition in a repetitive, blocked manner as is seen in Training Form practices (e.g. isolated skill practice). FFA's National Curriculum for the Game Training Phase recommends dividing the training session into four components- (a) the warmup or passing practice, (b) the positioning game, (c) game training and (d) training game. Components (b) to (d) would all be classified as playing form activities. The passing practice is generally training form;

> In terms of PERCEPTION-DECISION-EXECUTION, passing practices will focus on EXECUTION, as they are unopposed or use a rotating passive defender, but the clever coach tries to build in some PERCEPTION and DECISION (Cross, 2013, p99).

Given that decision-making in football is based on a player's perception of a range of factors including the ball, teammates, opponents and field position, coaches have generally accepted that decision-making is innate and developed by participating in the game rather than being trainable (Jordet, 2005; Williams & Hodges, 2005). However, studies that show that not only can decision-making be tested but that it can be trained, point to the processes underpinning expert decision making being a key area of interest for modern coaches (Gabbett et al., 2008; Lorains, 2013; Sweller, 2011; Ward &

Williams 2003; Williams, Davids, & Williams, 1999; Williams, Ward, Herron, & Smeeton, 2004; Wulf, McNevin, & Shea, 2001). When compared to other areas of sports science, skill acquisition is generally under-represented both in the applied and research fields (Steel, 2013; Williams & Hodges, 2005).

Development of superior perceptual-motor skills is designed to achieve more efficient and successful performance during competition (Rosalie & Muller, 2012). There has, however, been a lack of research that links decision-making to the game context (Bruce et al., 2009). The key issue with many laboratory based experiments is that results do not necessarily transfer to the game environment due to the large amount of sensory input during a game that cannot always be replicated (Williams & Ford, 2013). As highlighted by Rosalie and Muller (2012), transfer of perceptual motor-skill learning and performance to similar or dissimilar contexts is of key importance, "learning is inconsequential unless it positively influences behaviour at the time of performance" (p 417). It is the ability of players to transfer the skills developed in the learning environment (training) to the performance environment (match) that is of primary concern.

The aim of constraint manipulation in the training environment should be to become better attuned to the perceptual variables that will be encountered in the performance environment (Passos, Araujo, Davids, & Shuttlesworth, 2008). Extensive research has examined players' perceptual expertise, however there remains a lack of research-based training programs to improve and test perception in real match situations (Jordet, 2005; Jordet, Bloomfield, & Heijmerikx, 2013).

However, while there is limited evidence in the academic literature to support the effects of sports specific cognitive overload training for increasing perception and decision-making in footballers, there are a number of coaches incorporating cognitive load training into their coaching methodology such as Michel Bruyninckx and Kevin McGreskin in Europe (Sinnott, 2011). Both these coaches support the idea of overload training, "overload exercises help the player speed up the feet and the thought process" (McGreskin in Sinnott, 2011, p96) in order to ensure players are actively involved during an exercise, with examples including having players speaking in multiple languages and exercises that require players to throw a tennis ball and call out colours while passing the football. The idea behind this method of training is to enable the brain to deal with a similar or greater load to that experienced match situation in order to produce more effective footballers able to play passes at angles and at high speed. The underpinning idea of the training purported by both these coaches is to increase perception- both peripheral and split vision- and to speed up players' decision-making speed (Sinnott, 2011). The methods employed by these coaches and the anecdotal results of those methods support the idea of overload training in order to challenge players and develop both sides of the brain in order to increase perception and increase decision-making speed. However, there is currently a lack of academic literature investigating these methods. The necessary next step in the development of this training concept is to gather supporting evidence as to the effectiveness of the methods and their transfer to in match performance.

Aims of the study

This study aimed to build on the literature by developing practical training exercises that elicit the desired responses from the participants in terms of increased success of the perception-decision-execution nature of football actions and to examine the effects of multi-task and cognitive effort training during football practice and to determine their impact on decision-making regarding a player's first touch in the match environment. Specifically, it was hoped conclusions could be drawn as to whether this type of training leads to better perception and decision-making in relation to first touch under pressure in a football game situation.

Research Questions

Technical skills and decision-making are central to football and the process of perception-decision-execution are examined in FFA publications including the assertion that 'the development of football skill is inseparable from the development of perceptual expertise' (Williams cited in Cross, 2013, p200). The interdependence of perception, decision and execution is central to high-quality performance of football skill. The first touch a player takes when receiving the ball is critically important as it dictates their subsequent options.

It is the position of this study that, if perception is what underpins the quality of player actions, that this should be the starting point for developing the player's decision-making. It was proposed that improving the visual-spatial intelligence and visuo-motor coordination of players would lead to greater perception and cognition and result them being equipped with the tools to make better decisions in the game environment.

The following research questions were posed:

1. Will altering elements of the training environment lead to changes of the target groups' self-assessment of their decision-making ability

2. Does training lead to improved decision-making in a video-based decision-making simulation across both the target and control groups, with the target group demonstrating a greater level of improvement

3. Does training lead to improved first touch decision-making in the match environment, with the target group significantly improved after specific cognitive load training replacing the traditional passing practice during the intervention period.

Significance of the study

Football is the world's most popular sport with both participation rates and success on the international stage increasing over the past decade in Australia. In order to achieve the stated goal of making Australia a world leader in the sport, the Football Federation of Australia (FFA) released a National Curriculum detailing many aspects of world best practice to develop players and coaches including the need to develop expert decision makers (FFA National Curriculum, 2013).

There appears to be a gap in both the research and application in the sporting context as to the role and trainability of perception in football and whether greater perception of the in-game environment contributes to better decision-making. While decision-making is identified as being of critical importance in the development of elite footballers, there has been limited research undertaken examining the trainability of perception (Broadbent, Causer, Williams, & Ford, 2015; Memmert et al., 2009; Williams et al., 2004). Further, most testing has been done using laboratory testing with few studies looking into transfer to the match environment (Rosalie & Muller, 2012; Williams & Ford, 2013).

It is hoped that this study will add to previous literature, increase our understanding of skill acquisition and have practical implications for the development of Australian footballers with the potential for implementation in other sports. Following this research, this training strategy may be able to be introduced into specific training environments or have a wider impact on training methods.

Content of chapters

Chapter Two is a review of the key literature in the field of perception and decision-making and their link to expert performance. This begins with an overview of the characteristics of expert performers and the current training methods for attaining high performance. Subsequently, decision-making, decision training and players' self-assessment of decision-making are discussed. Next, the factor underlying decision-making; perception, cognition and visuo-spatial awareness are each analysed in order to form a firm understanding of the scope of this research.

Chapter Three outlines the research methodology undertaken during the project. This begins with the research design for the three facets of the study. First, a questionnaire was used to determine players' self-assessment of the effectiveness of the training methods. Subsequently, video-based decision-making test was used to determine player's football decision-making ability in the laboratory environment. The practical intervention then serves as the third part of the project. The procedure and nature of the intervention are discussed and an overview of the participants used in the study follows.

Chapter Four describes the results of the various elements of the study; questionnaire, video simulation and practical intervention. The results of the pre-test, post-test and retention test analyses are shown.

Chapter Five contains analysis and discussion of the results and relates these findings to the existing literature and the research questions posed in framing the study.

Chapter Six draws conclusions as to the effectiveness of the training methods, implications for both the research and practical setting and possible future directions for study in this critical area of decision-making during skill acquisition.

Definitions of key terms

Cognition- a collective group of thought processes (Lee, Swinnen, & Serrien, 1994).

Cognitive Effort- the mental work involved in making decisions (Lee et al., 1994).

Cognitive Overload- supply of too much information leading to the participant initially being unable to maintain their attention (Honeybourne, Hill, & Moors, 1996).

Decision- "Select an appropriate course of action" (Cross, 2013, p. 197)

Execution- "The player has to execute the chosen action with the appropriate qualities" (Cross, 2013, p. 197)

First touch- the first action undertaken by a player when receiving the ball.

Football- sometimes referred to as soccer, but referred to as football throughout this study given this is the internationally accepted term for the sport.

Motor performance- the challenge of motor control after a skill has been learned (Vickers, 2007).

Perception- "The player sees and hears what just happened and what is happening, then based on memory and experience tries to anticipate what will happen." (Cross, 2013, p. 197)

Visual-spatial intelligence- ability to comprehend the often abstract nature of the spatial organisation of moving athletes and objects (Vickers, 2007).

Visuo-motor coordination- the ability to use visual information to generate appropriate motor commands (Vickers, 2007).

CHAPTER TWO

Literature Review

The following review of literature attempts to synthesise the research-based academic literature with the methods being developed within the coaching world in order to develop a battery of exercises that can be used to develop perception and decision-making. Subsequently, the literature concerning valid and reliable testing and assessment of player perception and decision-making and the processes underpinning them within a dynamic team sport is reviewed in order to develop a reliable and consistent method for determining improvement in player decision-making in the real match situation.

Perception

Perceptual skill is a fundamental aspect of elite performance in sports (Luhtanen et al., 2004; Runigo, Benguigui, & Bardy, 2010; Williams & Hodges 2005; Williams et al., 2004). Being attuned to the most relevant perceptual variables is a key factor underpinning outstanding decision-making in football (Passos, Araujo, Davids, & Shuttlesworth, 2008). This is particularly important in football, where players are required to elicit information from the ball, team mates, opposition and space on the field before deciding and executing a response. While previous experience may enable players to consider a likely response, these task constraints shape emergent decision-making in each individual based on perceived information specific to the game environment (Passos et al., 2008). This requires players to focus attention on the most relevant source of information at the right time (Williams, 2000).

Perception and awareness of the constantly changing environment that characterises a complex and dynamic team sport such as football is essential in order to be able to make quality decisions within time constraints. Jordet, Bloomfield and Heijmerikx (2013) presented evidence suggesting that not only do expert performers have greater exploratory search frequency than other players, but that incidents of high search behaviour also corresponds to a higher pass completion rate. Using video images from 64 games in the English Premier League (EPL), the research examined the visual search behaviours of 118 footballers in 1279 situations in which the players needed to receive the ball closer to the goals than their teammate passing to them and their required exploratory behaviour to see what was behind them. Players who exhibited high levels of visual exploration completed 13.7% more passes in the opposition half and 23% more passes in their own half. A 17.9% increase in pass completion by midfielders with high exploratory behaviour was recorded when passing the ball forwards. However, this study also noted that visual exploratory behaviour itself is not enough to explain better vision as it does not take into account the perceptual-cognitive processes the player is undertaking. Perception requires the player to not only be able to see and hear the environment, but also to detect useful information and adapt their responses accordingly (Nyland, 2010). As such, it is both the exploratory search activity of the player and their performance with the ball that needs to be taken into account when determining level of perception (Jordet, 2005). Laboratory simulations generally fail to involve all the tasks and conditions that influence a player in a real match situation, such as information occurring behind a player's back, team playing style and game strategy (Jordet, 2005; Williams & Ford, 2013).

Direction of attention to important signals results in the body's sensory system learning to process these signals more efficiently than redundant signals (Yotsumoto & Watanabe, 2008). Literature exists demonstrating that perceptual skills can be enhanced through training interventions and "players' perceptual-cognitive skills are amenable to practice and instruction and, consequently, important tasks for coaches are to determine how best to design, implement and evaluate such programs" (Williams & Hodges, 2005, p. 648). However, Williams and Hodges (2005) rightly point out that these training interventions have generally focussed on either closed-skill tasks or anticipation and the authors note that there have been few attempts to improve other perceptual-cognitive skills.

In contrast, Memmert et al. (2009) explored three attention tasks to determine whether team sports training improves attentional skills and/or whether those that have greater attentional ability excel at team sport. Using 120 participants divided into three categories, experts in team sports, experts in non-team sports and non- or novice athletes, the study was administered using computer based tests. Their findings supported previous non-football specific literature (Abernethy, Neal, & Koning, 1994) that athletes are no better at basic vision perception compared to non- or novice athletes but also suggested that expertise does not lead to basic differences in attention.

While there are no reported physical differences in vision between players of different expertise levels, the visual search behaviour does differ. Vaeyens et al. (2007) investigated visual search behaviour in football and its correlation to decision-making. Using five categories of small sided games and participants of various skill levels, the study was based on the hypothesis that increases in the number of players and a lower offensive to defensive player ratio would increase task complexity and decrease response accuracy. The study used a video-based test to examine both the effect of differing numbers of players on the screen on visual search behavior and how players of different ability levels extracted information from the visual display to inform their decision-making. Elite and sub-elite participants performed better than regional level players on decision-making tasks, though it was also concluded that attempting to teach players to mirror search patterns was likely less effective than using guided discover or discovery learning. Elite players were shown to alternate their gaze across a wider range of fixation points across the display and adapt their visual search strategy according to task constraints. As is the case in most visual simulation tasks, this study focused on the differences in search behavior and perception between players of differing skill levels, rather than whether players of the same skill level could be trained to have greater visual search strategies and perception.

In order to better understand the link between visual search and thought processes underlying skilled performance, Afonso, Garganta, McRobert, Williams and Mesquita (2012) recorded both eye-movements and verbal reports of 27 female volleyball players divided into 'highly skilled' and 'skilled' groups. While participating in a 6 v 6 simulated match, the researchers tracked players' eye-movements and collected immediate retrospective verbal reports of the thoughts behind actions. The visual search behaviours of the 'highly skilled' group differed in that they fixated on a greater number of locations combined with significantly more sophisticated statements. The research concluded that game constraints created by opponents are better recognised and understood by highly skilled players than their less skilled counterparts.

Furthermore, Roca, Williams and Ford (2012) examined whether footballers' perceptual-cognitive expertise could be differentiated based on their developmental activities with skilled and recreational players undertaking interactions with life size video sequences filmed in the first person. Player decisions were then compared to the decision-making of a panel of three UEFA qualified coaches. Links were drawn between the hours of practice participated in and the level of performance. Given that the expert groups undertook greater hours of practice than the non-expert group, the study is limited in determining whether higher perceptual-cognitive ability contributes to expert performance or is merely a by-product of greater hours spent in purposeful practice. The authors promote future research that includes an experimental design with controlled interventions to explore causal links between certain types of practice and specific adaptations in performance attributes such as decision-making

Williams et al. (2004) used video simulation, instruction on situational probability and task performance feedback to test whether a player's ability to anticipate opponents' intentions was trainable. While limited given the small sample size (n=16) and that novice players were used and that it was a solely laboratory based study, the results did indicate that perceptual skills can be developed through appropriate training.

Perception appears to be a trainable skill with appropriate instruction. However, there remains a lack of reliable evidence suggesting methods for training, testing and transferring increased perceptual skill to the match environment.

Decision-making

Decision-making in high performance sport has been widely researched (Berry & Abernethy, 2003; Berry, Abernethy, & Cote, 2004**;** Furley, Bertrams, Englert, & Delphia, 2013; Gabbet et al., 2008; Lorains, 2013; Vaeyens et al., 2007; Williams & Ford, 2013). While it is widely accepted that skilled perception precedes appropriate action, with skilled performers' enhanced cognitive knowledge enabling a greater interpretation of perceptual information, it has also been argued that not all elite players are exceptional decision makers given the multifaceted nature of the skills and attributes (strength, speed, resilience etc.) required to achieve excellence in team sports (Vaeyens et al., 2007). It should also be noted that Williams and Hodges (2005) have discussed the difficulty of assessing the effectiveness of behavioural and social sciences in comparison with physical sciences given that "constructs such as anxiety, self-confidence, anticipation and decision-making are difficult to measure directly and can only be inferred from changes in behaviour over time" (p. 637). Despite this difficulty, the identifying and training of expert decision makers remains a high priority both in the literature and in the practical setting.

Bruce et al. (2009) presented findings that demonstrated differences in the level of decision-making complexity between elite and developmental netballers. The study involved presenting players with different and more structured styles of defensive pressure in the match environment. Experts were shown to consistently make more complex decisions than development players, indicating that performance at an elite level does in fact require an 'elite' level of decision-making.

Similar conclusions as to the increased complexity of decisions made by experts were shown when Stevenson (2013) conducted a study of football and hockey players' decision-making across four methods of investigation. The four studies examined anticipatory performance of players of various abilities, domain specific knowledge, verbal justification of decision-making and, finally, tactical awareness of typical in-match situations. Results indicated that elite players' decision rationale was more grounded in tactical and strategic knowledge with a greater understanding of the consequences of potential actions.

> Given the skill level of the elite player, it is likely that they will be able to execute the skill. However, a more salient point emanating from the findings is that the elite player will also derive explicit knowledge which guides strategic deployment of that skill. That is, there is a conceptual understanding of when and why that particular skill should be executed in a given instance (Stevenson, 2013, p. 135).

Elite players' greater technical ability enables them to draw on a wider procedural knowledge base when deciding on a course of action and rationalising the reason for the chosen option (Stevenson, 2013).

Task attention and self-control resources are also identified as key elements of high level decision-making (Furley et al., 2013; Memmert et al., 2009). Furley et al. (2013) focused on the need for athletes to maintain focus on performance while blocking out irrelevant distraction based on the availability of sufficient self-control measures. Using a sample of forty basketball players responding to stills from televised matches, participants were instructed to make tactical decisions based on three alternatives within a specified time limit. The study used 116 stills that had previously been viewed by two experts who had rated the most appropriate decision to be made. Players were required to choose whether to shoot, dribble or pass. The experimental manipulation then required players to retype a text as quickly and accurately as possible with one group (ego-depleted group) task requirement requiring far more attentional resources. The ego-depleted group performed significantly worse on the tactical decision-making task indicating that sufficient self-control is required to focus attention on task performance. While the research is limited, in that the decisions being made were displayed via still photographs and participants responded via a keyboard based testing mechanism with limited applicability to the 'real' game environment, the impact of distraction on the tactical decision task was clear. This points to task attention being a key facet in the decision-making process.

Clearly there are a number of important and inter-related factors that both inform and underpin expert decision-making. Grehaigne, Godbout and Bouthier (2001) highlighted the interdependent nature of the range of considerations faced by players when making decisions and that the validity of those decisions is based on efficient translation of decision to action. Consequently, Grehaigne et al. (2001) classify the individual aspects of decision-making as individual strategy (planning ahead), the player's cognitive map or knowledge base (declarative and procedural knowledge through past experience), tactical knowledge (notions extracted from practice), resources (motor competencies, concentration level and motivation) and the player's location and posture.

Cognition

Both high level perception and decision-making require an advanced level of cognitive ability in order to both extract and interpret the information on offer and to determine the best course of action. The importance of cognition in the development of complex motor skills has also been the subject of a number of studies (Lee et al., 1994; Moreau, 2015; Ward & Williams, 2003). It has been argued that if the cognitive activities being undertaken are too far removed from the goals for the task that skill acquisition can be impeded (Chandler & Sweller, 1991). In a dynamic sport such as football, a high level of cognition is important in order to assess the range of options available to the player with the ball. The development of optimal synaptic linkages that can both detect and process objects, events and locations within the environment is essential to high performance in sport (Vickers, 2007). There has been debate within the literature as to whether the brain has fixed or flexible attention capacity and whether it is able to attend to multiple tasks which share common resources (Memmert et al., 2009; Vickers, 2007; Williams et al., 1999). Vickers (2007) promotes the notion of dissociation, whereby the athlete is able to split the locus of the gaze and the locus of attention.

In discussing cognitive theories of attention, Williams, Davids and Williams (1999) reviewed four different historical models of attentional capacity. Fixed capacity models suggest that after a players' capacity has been exceeded by the number or complexity of the tasks they are presented with, that performance will deteriorate. Flexible capacity models promote the notion that more capacity can be made available and that the capacity changes according to the task requirements. Multiple resource models conceptualise attentional capacity as being divided into a number of independent pools, therefore it is only concurrent tasks of the same nature that can be detrimental to performance. The final models that are presented are networks of attention, whereby multiple nodes make up a network with several nodes capable of output at the same time and experiences leading to changes in the pattern of connectivity between nodes. Finally, Neumann's functional view of attention suggests

> …it is the selectivity of action that explains why capacity is limited, contrary to the traditional view that selection is needed due to the restricted capacity to process information…it is not perception but action, and not the capacity of the central information-processing system, but the capacity of the body that makes selection necessary (Williams et al., 1999, p. 40).

This model promotes the view that many processes can run in parallel during the selection of action, but after the appropriate action has been decided upon, other processes that may cause interference are completely or partially blocked.

The importance of enhanced cognitive skills has been espoused with advanced perceptual-cognitive levels demonstrated in elite football players as early as nine years of age (Ward & Williams, 2003). In their study of 137 elite and sub-elite male footballers aged 9-17, players were tested using four measures of visual function as well as anticipation, memory recall and situational probabilities. The variables shown to define expert performance were perceptual and cognitive rather than visual. High quality coaching at a young age was shown to have a marked impact on perceptual and cognitive skill acquisition. Ward and Williams (2003) concluded that while technical skills should be the focus of instruction at an early age, the inclusion of perceptual and cognitive skills training would be beneficial for developing appropriate game-reading skills.

Building on this evidence of increased cognition in elite performers, it is the trainability of increased cognitive performance that is of most interest to the present study. There has recently been a growing body of work that explores the plasticity of the brain and the manner in which purposeful practice has a positive effect on brain function (Colvin, 2010; Coyle 2010; Scholz et al., 2009; Syed, 2010). Studies have shown that the learning of a new skill alters both the functioning and the structure of the grey matter and myelin of the brain (Scholz et al., 2009). Studies have also been undertaken outside of football into the effect of learning visuo-motor tasks on cognitive performance, finding that the brain undergoes noticeable structural changes when confronted with a complex task (Hitchins, 2012; Jenerou et al., 2015).

In the practical setting, Lennemann et al. (2013) studied the effects of agility training on cognitive performance when compared to a control group that undertook regular physical training. The program was implemented three times per week for six weeks using 45 members of the US Air Force. Cognitive performance testing was conducted to assess working memory, sustained memory and dichotic listening. The agility training included cone drills, ladder drills and hurdles. The ladder drills consisted of a number of sequences with increasing difficulty throughout the six week period including fast feet, icky shuffle, scissor, fast feet backwards, fast feet to the side while catching a reaction ball and hopscotch. In the post-test, the agility training group displayed significant improvement in both the continuous memory and visual vigilance tasks while the physical training group did not. This study suggests agility training may be a viable tool for improving cognitive performance, further evidence that not only do elite performers have a heightened cognitive level, it is a trainable aspect of performance.

Visuo-spatial awareness

The ability to correctly and consistently make good decisions under temporal pressure is the foundation of visual-spatial intelligence and a key requirement of sport (Vickers, 2007). Vision is the dominant sensory system leading to perception of information to be interpreted and an appropriate physical response generated (Clarke et al., 2015; Vickers 2007). It has been noted in recent literature that while sports teams devote time and resources to many aspects of performance, there is relatively little time devoted to training of the visual system (Jenerou et al., 2015). There is contrasting research examining whether performers have greater visual function than non-elite players with debate as to whether visual acuity, stereoscopic depth and peripheral awareness differ (Jenerou et al., 2015; Marquez, 2010;).

Trainability of the visual system within the sporting context has led to some interesting and important conclusions with ice hockey and American football players participating in targeted interventions (Clarke et al., 2015; Jenerou et al., 2015). Jenerou et al. (2015) implemented a six week training intervention with vision training conducted 2-3 times per week. The training focussed on increasing binocular vision skills and dynamic skills such as reaction time, eye movements, visual memory and peripheral awareness. The study intervention was conducted in a laboratory setting and while the visual skills being improved are of importance in ice hockey, the intervention itself did not necessitate executing game-specific tasks, though this is acknowledged by the authors. Despite this limitation, there were significant differences in pre- and post-intervention performance including a 4.7% increase in post-vision training shooting percentage. Athletes also provided qualitative evidence for the success of programs focussed on increasing vision, with feedback provided ranking vision as more important to success following the training program than had been the case prior to the intervention.

Furthermore, exercises that require multitasking to perform a visuo-motor skill requiring the coordination of both physical movements and visual stimuli, such as juggling, have been proven to increase and change brain matter, particularly in the areas related to actions in the periphery of vision (Scholz et al., 2009). Interestingly, these changes were not shown to significantly correlate to the level of attainment of the juggling skill pointing to quantity being the key determinant of change. That is, the more juggling that was performed the greater effect it had on the brain regardless of how well that juggling was performed. As an example of the effects of training visuo-motor tasks, juggling has been examined to determine the impact it has both on the brain and on cognitive function, with evidence suggesting that there are structural changes due to the nature of the task, including noticeable changes to the brain’s grey matter and myelin (Colvin, 2010; Hitchins, 2012).

Visuo-motor coordination, whereby the brain generates appropriate motor commands based on visual information and the subsequent visuo-motor performance after initial learning of the skill, form the basis of skilled motor performers. Also referred to as perception-action coupling, the performer is required to initiate and execute an action based on one or more moving objects is a critical aspect of motor skill performance, yet there is little research examining the acquisition of this coupling (Magill, 1998). In a study designed to determine whether explicit knowledge of the environmental regulatory features involved in skill acquisition is essential, Magill (1998) replicated and then extended an experiment requiring students to perform a complex waveform tracking task for 14 days. In the initial experiments, the middle segment of every waveform was the same. In the second experiment, the first segment of the waveform was repeated in every trial. Participants performed significantly better on the segments that they were repeating, yet none verbally reported awareness that the segments were the same on every trial. Consequently, the conclusion can be drawn that awareness and performance can be acquired in a laboratory setting through training and repetition even without participants being explicitly aware of the process taking place. However, the study does not address whether the acquisition of this implicit awareness transfers to other tasks or domains apart from the single measure used.

Automaticity

One of the key themes in the literature surrounding expert performance is the importance of skills having an automaticity to be able to be performed with accuracy and precision and this has been previously shown with conclusions drawn as to the importance of performing components of a skill without conscious attention during competition (Gorman, 2008; Syed, 2010, Williams et al., 1999). A reduction in the amount of attentional resources required for a technique, the greater the capacity to allocate resources to concurrent activities (Williams et al., 1999). While in the novice stage of skill development attentional commitment is required for controlling task performance, once it has been relatively well learned, extra attention becomes available for concurrent tasks without significant impact on the primary task.

It has even been suggested that attention to performance can be adversely affected with the development of automated performance (Beilock et al., 2002). Using a study of experienced and inexperienced footballers, it was shown that while during initial stages of skill acquisition it was beneficial to focus attention on each component of the skill, in later stages of performance this can be detrimental. This study observed novice and expert players performing tasks with a skill-focused manipulation and then with a dual-task condition. While the novices performed better when there was a focus on the skill, experts actually performed at a lower level with this single focus and better when faced with a dual-task. This is likely due to the focus of attention on the task leading to their performance no longer having automaticity. This study demonstrates that expert performers do not require constant attention to the primary task during execution, allowing them to devote attention to secondary tasks such as visual awareness and decision-making.

Studies have also shown that contextual interference and random practice which do not allow for automaticity during training is most beneficial (Vickers, 2007; Wilde, Magnuson, & Shea, 2005; Williams & Hodges, 2005). However, reducing the attentional resources required to achieve a task or outcome is a fundamental objective of training in order to develop automaticity during performance (Williams et al., 1999). Furthermore, Gorman (2008) identifies three key strategies for implementation by coaches to avoid drawing attention to the step-by-step components of the skill in competition and to promote automaticity. Cue words, alternative points of focus and analogy learning are proffered as techniques that can be used to avoid the colloquially termed 'paralysis by analysis'. As such, a training program that avoids automaticity during learning and development and simultaneously leads to greater automaticity during competition would appear to be ideal as this would provide maximum learning through adaptation to constant challenges in the training environment while minimizing the need for explicit task attention during performance.

In order to avoid automaticity, the learner must be consistently challenged. The training of motor skills has been demonstrated to be superior when using a random order approach which requires greater cognitive effort resulting in a better contrastive knowledge of tasks and greater retention (Lee et al., 1994). Williams and Hodges (2005) observe that coaches typically judge effectiveness of a training session by observing players' performance during the training session and that this may not be reflective of performance progression over an extended period of time. Further, they contend that variable and random practice should be progressed more quickly than in traditional models of coaching. Of greatest importance to the present study is the assertion that the acquisition of game intelligence (decision-making and anticipation) can be developed through appropriate intervention, though video-based interventions are the key focus of the review.

In the sports domain, declarative knowledge is knowing 'what to do' (Stevenson, 2013). Adaptive control of thought theory promotes the notion that the performance of a task leads to the acquisition and retention of specific declarative knowledge, though many studies investigating the development of this knowledge have only focused on one measure of task performance (Williams & Davids, 1995). During a study involving three groups of participants (12 experienced high skill footballers, 12 experienced low skill footballers and 12 experienced spectators with no playing experience) across three measures of task performance, Williams and Davids (1995) found evidence that supported their hypothesis that rather than being a by-product of experience, declarative knowledge is a constituent of skill. High skill players outperformed others on an anticipation test, recall test and pattern recognition test. The study concluded that the acquisition and retention of declarative knowledge is promoted through procedural knowledge, "that is, knowing facilitates doing and doing facilitates knowing" (p. 272).

Above all, the findings of the study indicated that a greater knowledge base is a characteristic of expert performers and that expert knowledge is acquired during the performance of tasks. While it has been noted that cognition perception and decision-making can all be developed and appear trainable, limited research suggests how this is best achieved.

Training decision-making

Recent literature has focussed on the characteristics of expert performers with a key assertion being that deliberate and purposeful practice is key to attaining an expert level of performance (Andrzejewski, Chmura, Wiacek, & Zubrzycki, 2011; Baker, Côté, & Abernethy, 2003; Colvin 2010; Coyle, 2010; Ford & Williams 2013, Syed, 2010; Williams & Ericsson, 2005). Tactical expertise (doing the right thing at the right time) is essential for expert performance in sport (Kannekens, 2011), while Baker et al. (2003), identified superior perceptual skills, superior decision-making skills and superior movement execution skills as being the key determinants of experts with deliberate practice the defining element of expert training loads. It is the ability to adapt to changing situations and an inconsistent environment that is the key indicator of successful skill transfer (Rosalie & Muller, 2012). In order to achieve excellence, a considerable amount of time must be spent on practice, with individual motivation, hereditary and environmental factors also significant (Williams & Hodges, 2005).

Two main forms of practice are generally found in youth football; Training Form (drill-type practices such as passing drills) and Playing Form (match-like activities such as small sided games) (Ford et al., 2010). Training form activities generally train individual constituent parts of a skill until they become at least partially automatic before progressing toward match-based activities. Training Form activities can lead to acquisition of technical skill without the required perceptual-cognitive skills such as decision-making while Playing Form activity is more likely to develop these skills (Cushion et al., 2012). Playing form activities are promoted as superior for the development of perceptual-cognitive skills which are an important aspect of football (Ford et al., 2010; Williams & Ward, 2007) and more relevant for transferring to competitive performance. Ford et al., (2010) conducted a study analysing a total of 70 training sessions conducted by 25 youth coaches working in elite and non-elite youth football in the UK. Training Form activity accounted for 65% of overall training time, with playing form activity accounting for 35% (Ford et al. 2010). A lack of Playing Form activities can have a negative effect on player development (Cushion et al., 2012). In contrast, model sessions under the FFA National Curriculum are designed to have three of the four components (positioning games, game training, training game) constituting Playing Form (FFA, 2013). There appears to be a gap in the literature as to the ideal ratio of Training Form and Playing Form activities for optimum player development.

Retention and transfer of learning into the complexity of on field performance is the key consideration of any training method (Broadbent et al., 2015). Given the emphasis that is placed on developing skilled performers and educating both coaches and athletes, there is a lack of understanding and utilisation of experts in the field of skills acquisition (Steel, Harris, Baxter, & King, 2013) and research identifying and implementing the important elements of effective practice (Williams & Hodges, 2005).

Experts acquire complex skills enabling them to both store more information in long-term memory and expand the capacity of short-term memory (Williams & Ericsson, 2005). The expert performance approach is characterised by determining how experts acquire skills which lead to consistently superior performance. While most of Williams and Ericsson's (2005) review focused on retrospectively determining the level of perceptual-cognitive expertise rather than the development of this factor, they importantly encourage research to focus on long-term interventions with realistic simulations of the performance environment designed to identify changes to the underlying mechanisms of expert performers. The authors note that simplistic laboratory tasks may cause experts to use different information to that they would use in a match situation in order to achieve their tasks, potentially leading to floor or ceiling effects on performance. Evaluating performance over a period of time in related scenarios may help to address issues of realistic and reproducible results.

In examining what methods athletes identify as being important in the development of perceptual and decision-making skills, Baker et al. (2003) conducted a study examining the activities of 15 Australian national team athletes across a range of sports and compared them to the activities of 13 non-experts with over 10 years' experience in their sport. However, a limitation of this study was there was no classification of the control group based on perceptual cognitive expertise and that the ratings of elite players were solely based on potentially subjective opinion of coaches (Williams & Ericsson, 2005). There were also reliability issues surrounding the interview task that formed the basis of their findings as they relied extensively on athletes' retrospective recall, though this is acknowledged by the authors themselves. Despite these limitations, the findings provide an important insight into activities that athletes considered helpful for developing both perceptual skills and decision-making, namely; competition, organised training and watching games on television.

Traditionally, methods of coaching decision-making in team sports has been deterministic, with a focus on automaticity of skill performance, without taking into account the need for players to be able to adapt to a constantly changing dynamic environment (Passos et al., 2008). The importance of developing training sessions that use a decision training approach which emphasises cognition is of vital importance (Broadbent et al., 2015; Vickers, 2007). Decision training is preferable to behavioural training, which leads to immediate positive gains but over time performance declines. This is the case especially when difficult and stressful conditions are encountered. With decision training, although performance may be depressed initially, in the long term athletes continue to improve and ultimately perform at a higher level (Broadbent et al., 2015).

Decision training requires greater cognitive effort coupled with physical training, leading to greater permanent gains (Vickers, 2007). Broadbent et al. (2015) have argued that well designed physical practice should take priority in order to maintain the coupling between perception, cognition and action. They further proffer that simulation training for perceptual-cognitive skills should promote high contextual interference (CI) given the long term benefits of this form of practice for long term learning and skills transfer. An example of a practice with high CI is when players practice a variety of distinct skills (in a football context this could be; first time pass, first time control, first time shot) in a quasi-random order (small sided game) compared to low CI when practice is in separate blocks of one skill (passing in pairs).

Likewise, Williams, Ward, Smeeton and Allen, (2004) have demonstrated that training in a multisensory environment that require learners to physically respond to visual, tactile and auditory information is a key facet in developing skills that will transfer to the game environment. Their study involving 24 recreational tennis players examined whether perceptual training requiring a physical action response (perception-action) was more effective than perception training which required anticipation without a linked action response (perception only). A third group was used as a control and received only technical instruction. Results indicated that both the perception-action group and perception groups had significantly improved performance in the post-test compared to the control group. While this study did not observe any significant difference between the perception-action and perception only groups, the study is limited given that it did not observe the execution of the return stroke and only focussed on anticipation of the opponent's serve and as such does not truly determine the value of this form of training for transfer to the game environment.

Similarly, the differential training method is characterised by presenting exercises in a random order to necessitate a more complete scanning of solutions. The nature of differential training for goal-kicking by moving away from traditional training techniques that focussed on repetition of a programmed series of exercises and toward exercises that require participants to problem-solve has also been examined (Trockel & Schollhorn, 2003). For example, rather than practice the chip until it is perfected then moving on to another goal scoring method, players are forced to choose the appropriate technique (type of kick) for each situation as it is presented.

The non-linear nature of learning through a differentiated learning approach using football as a focus is further examined by studying the effects of learning two movement techniques and the development of more functional movement patterns with positive outcomes for groups trained using this approach (Schollhorn, Hegen, & Davids, 2012). The study involved testing players' ability to control a ball in minimal space and their shooting accuracy with 20 exercises for each of these two techniques (40 exercises in total per training) trained over a four week period. The control group performed each of the techniques separately in a linear blocked manner, a second group (differentiated blocked group) performed exercises for both techniques together in a blocked order, while a third group (differentiated random group) did them in a random order. Significant difference was found between the control group and the two differentiated learning groups. The authors of this study present a case for movement variations rather than movement repetitions as the basis of learning, while also presenting evidence of greater skill acquisition and retention rates using this approach. The small number of participants (only 50% of the original 24 were able to participate in all testing and training sessions), does mean that the results must be treated with some caution.

Dual/multi-task training

The positive effects of multitasking, also described as split attention training and dual-task training during skill development and learning, has been the focus of multiple studies designed to challenge the learner to store information in their working memory (Beilock et al., 2002; Sweller, 2011; Williams et al., 1999; Wulf, McNevin, & Shea, 2001). Successful dual task performance requires the ability to rapidly switch attention from one area to another, as performing tasks concurrently has been shown to decrease performance in the primary task (Williams et al., 1999). Skilled performers can assign less attention to the primary task, enabling them to direct attention to the secondary task

(Williams et al., 1999). In a football context, a primary task would be controlling the ball with the first touch, while a secondary touch would be scanning for passing opportunities. Further, Wulf, McNevin and Shea (2001) examined the impact of attention focus on automatic control processes during skill acquisition through a dynamic balance task with participants required to focus attention either internally or externally. Using a dual-task procedure, with participants required to perform a stabiliser task while responding to randomly presented stimuli, they found that an external focus of attention increased balance performance, increased response frequency and decreased attention demands leading to greater learning benefits.

In addition to the demands of multitasking, the attentional control of expert performers to avoid internal and external distractions during the decision-making process has recently been a focus (Vickers, 2007; Vine & Wilson, 2011). Directing attention internally toward task performance and the skill process can lead to a breakdown in performance (Jackson & Beilock, 2008). Jackson and Beilock (2008) discuss the evolving line of research involving performers learning skills with minimal focus on the explicit rules or instructions of performing those skills with results indicating that less focus of attention is required and the skills become more robust under pressure. For example, actively focussing on an external visual cue, such as the dimples on a golf ball, has been is promoted as a strategy beneficial to performance. However, this process is generally discussed in reference to self-paced or closed skills such as golf, free throws in basketball or a penalty kick in football.

Vine and Wilson (2011) conducted a study examining the effects of quiet-eye (QE) training whereby attention is focussed on the relevant target at the moment of execution. The study was designed to ascertain whether players who had participated in QE training would perform better than those that had received just technical instruction when learning basketball free throws. While there are limitations in the application of this study, given that the players were novices and the task being undertaken was static and does not reflect the full demands of basketball, it is important as it demonstrates that attentional control is trainable and that the focus of attention during key movements is an important aspect in attaining high quality skill execution.

Focussing attention on strategy (what to do) rather than on technique (how to do it) has also been shown to help prevent skill failure in skilled soccer players (Jackson, Ashford, & Norsworthy, 2006). Players were required to dribble through a series of cones while setting themselves a focus of attention. Those that chose a goal related to strategy for successfully completing the task were more successful than those that focussed on the technique required to do so. Jackson and Beilock (2008) term this the *paradox of control* whereby focus on elements of skill performance that the player believes will enhance outcomes can actually result in poorer performance. This provides a valuable insight into the effects of attentional focus. While not a self-paced skill such as putting and clearly more applicable to football, this is an isolated skill in the laboratory environment and there is no indication of transfer to the match environment in this study. However, given that strategic thought processes generally require thinking about multiple inputs of information, this may also lead to an improvement in decision-making (Jackson & Beilock, 2008).

Video-based simulation training and testing

Video-based simulation training and testing uses game specific video segments with players required to respond by making the decision or anticipating the action that should occur in a match environment. Simulation training and/or testing has been used in an attempt to assess and/or enhance anticipation and pattern recognition in a number of studies (Gabbett et al., 2008; Lorains, 2013; Lorains et al., 2013; Ward & Williams 2003; Williams et al., 2004). Video is an objective method of evaluating performance as it enables sequences to be reproduced in a consistent manner (Williams & Ericsson, 2005). However, while video-based simulation generally leads to superior performance, there has been criticism of it as a reliable testing tool, as different processes may be being used compared to those required in a match situation (Afonso et al., 2012).

One of the key issues of video-based training is selecting appropriate clips from suitable angles in order to engage the athlete and make them feel that the decisions being made resemble a real match scenario (Lorains, 2013). Fidelity refers to the realism of the simulated environment to the real thing with Stoffregen, Bardy, Smart and Pagulayan (2003), defining the appearance of the simulation as physical fidelity and the feel of the simulation as psychological or experiential fidelity while pointing out that simulations should reflect realism and that they are unlikely to reflect reality. The video simulation method has drawn criticism as some researchers feel that the task is too far removed from real performance to require true responses (Farrow & Abernethy, 2003 cited in Lorains, 2013).

Despite these criticisms, perceptual training through video-based training has been shown to enhance decision-making ability in a study examining the effects of perceptual based training in elite women soccer players (Gabbett et al., 2008). In this study which looked into the effect of enhanced perceptual skills on the physiological demands of in-game activities, players were tested before and after a four week period. While no significant changes were detected in physiological assessments during this period, decision accuracy improved and recall errors decreased indicating that perception training through video-based tasks can lead to improved decision-making in both off and on field assessments.

The trainability of decision-making has further been examined to determine the quality of decision-making using an above real time training method in Australian football (AFL) players (Lorains, 2013; Lorains et al., 2013). These studies used video from games sped up to 150% of real time in order to replicate the temporal pressure for making decisions, leading to conclusions that this increased speed increases the fidelity of the simulated environment and forces athletes to focus with increased automaticity. Responses were compared to those of elite coaches. The lack of statistically significant difference between groups in the match setting indicates that while decision-making can be trained using above real time video in the laboratory setting with positive results, this type of training may be limited in its applicability for increased performance.

Video testing alone is limited in that it does not take into account the visual and auditory cues that surround a player on all sides during the decision-making process in an invasion sport. Further, there is currently a lack of reliable evidence to suggest transfer of learning to the match environment.

Assessing Match Performance

Assessing match performance in invasion sports such as football is particularly challenging given the number of on and off the ball actions undertaken by players and the difficulty in separating decision and execution with a number of assessment tools used (Blomqvist, Vantinnen, & Luhtanen, 2005; Gabbett et al., 2008; Lorains, 2013; Memmert & Harvey 2008).

Blomqvist et al. (2005), identified the key issue of testing decision-making performance objectively through standardised tests that do not take into account the players' ability to execute the actions being proposed. Their study, involving secondary school students aged 14-15 years participating in both a video-based understanding test and in modified 3v3 soccer games examined the link between game understanding and ability to respond to game situations when they are presented. They noted that measuring game understanding in standardized settings by assessing the actions taken by players in response to various game situations is potentially clouded by whether or not the players have the ability to decide what to do and to execute this correctly in response to the game situation that confronts them. The Game Performance Assessment Instrument (GPAI) was proposed as an authentic instrument when assessing team spots. The purposes of this study were to assess students' game understanding and game performance and to investigate how game understanding assessed by a standardized video-based test corresponds to students' decision-making and skill execution ability in actual game play. Video sequences involved 4-7 seconds lead-up followed by 15 seconds to choose from 3 options presented, with responses then assessed against the decisions of two experts. A strong relationship was found between game understanding and decision-making in the match environment.

However, the reliability of testing instruments, including GPAI, was examined by Memmert and Harvey (2008). The GPAI is designed to allow teachers or coaches to select one or more elements of the game in order to assess players' performance. Memmert and Harvey (2008) identified five areas of concern with the instrument. A key issue is that the instrument can result in a player not registering either appropriate or inappropriate for a particular game component and consequently, a player who made 10 inappropriate actions and zero appropriate actions is rated as equal to a player who made two inappropriate action and zero appropriate actions. A further important criticism of the GPAI is the difficulty in realising appropriate or inappropriate actions when coding off-the-ball actions and the potential impact that this can have on assessing a player's performance if these actions are included in the overall assessment.

Self-assessment of decision-making

Players' perception of their own decision-making ability is an important aspect of player confidence (Ruiz Perez, Nieto, Coll, Manzano, Espin, & Psotta, 2014). Ruiz Perez et al. (2014) identified decision-making in sport as both a cognitive and emotional process and investigated the impact of the personal and subjective perceptions of athletes. Using a study of 690 football players, participants completed a decision-making in sport questionnaire which showed that self-perception of decision competence changed according to experience and expertise level. It is argued that confidence in one's own decision-making resources should be a key consideration of coaches. The study is limited however, as it did not link player's confidence in their decision-making to their real or perceived perceptual-cognitive ability, not did it correlate athletes' self-assessment of their decision-making ability to any evidence of their actual decision-making in the match environment.

In a study of 105 players which tracked them from elite youth footballers into adulthood, Kannekens, Elferink-Gemser and Visscher (2011) found that midfield players who were assessed as scoring highly in 'positioning and deciding' (taking up positions and making decisions when they received the ball) were 6.6 times more likely to become a professional than lower scoring players, though it must be noted that this was based on players' self-assessment of their relative strengths and weaknesses. This study is limited in its use for assessing decision-making competence, particularly given the lack of an experiment to determine a causal link. While caution must be taken when interpreting the results given the limitations of the study undertaken by Kannekens et al. (2011), the results do point to decision-making being an important factor in football success.

Self-assessment of decision-making ability does however present a range of issues, particularly if it is not coupled with an objective measure of decision-making in the match environment. Kannekens, Elferink-Gemser, Post and Visscher (2009) investigated self-assessment of tactical skills in 191 youth players between 14 and 18 years of age through yearly completion of the Tactical Skills Inventory for Sports between 2001 and 2008. This study specified decision-making competency according to player positions, with different criteria for each position. The results showed greater progression in the self-assessed decision-making of attackers. However, the differentiation of scale according to position makes it difficult to objectively compare or for meaningful conclusion to be drawn. The key limitation of the study is that too greater emphasis is placed on decision-making within specific roles of positions, rather than decision-making on the whole given the fluid nature of positional play in football.

Interestingly, recent studies have suggested that athletes' perception of their ability is often inaccurate as it is based on an assessment of their peak ability rather than on their average base ability (Guenther, Taylor, & Alicke, 2015). In two studies involving collegiate baseball players and collegiate softball players respectively, Guenther et al., (2015) investigated players' self-assessment of their ability compared to their teammates. The majority of players believed themselves to be better than their teammates and better than the average player in their competition. This was not reflected in their on-field performances. Players also perceived their best performance of the season to most accurately indicate their true level of ability. Further, the least skilled individuals were shown to be the most likely to overestimate their ability in line with previous studies (Guenther et al., 2015).

Summary

It is clear that the ability to make good decisions and execute them under pressure is a key aspect of football at the elite level. The process of perception-decision-execution is critically important in designing training sessions and exercises for optimal learning and transfer to the match environment. While there are a wide range of studies examining different aspects of cognition, perception and decision-making, there remains a gap in the literature regarding training of these aspects of performance and testing the transfer of learning to the match environment. The above review of literature indicates that cognitive load training may be a viable tool for increasing perception and decision-making and that dual/multitask training has a positive impact of players' ability to perform primary and secondary tasks within the match environment. Separating decision from execution when assessing players' decision-making ability is an important consideration when assessing performance.

Implementing a range of testing measures to examine transfer of learning to both the simulated and match environment is vital, though caution must be exercised when attempting to assess too many aspects of performance, particularly given the subjective nature of decision-making. The key role of first touch in football and the necessity for this to be underpinned by good decision-making at the elite level indicates that this is a vital starting point when assessing on ball decision-making capability.

CHAPTER THREE

Method

Research Design

The study involved an experimental design using a control trial during the intervention to eliminate confounds that could otherwise explain results (Schneider, 2013). Factors that were considered include a control group, assignment of players into the intervention and control groups based on surname and a consistent opponent for all matches. This fits the parameters of a true pre-test – post-test randomised groups design (O'Donohue, 2010) in order to ascertain whether differences in performance of the groups existed before the study and allow direct comparison between the two experimental and control groups' performances over the intervention period.

The effectiveness of the training intervention was assessed via three methods. First, participants undertook a video-based decision-making test. Second, participants completed a questionnaire self-assessing their decision-making capabilities. Third, notational analysis from three experts watching video footage of games before and after the intervention and two weeks post-intervention as a retention test was used to assess players' decision-making. Three experts were chosen in order to attain objectivity and reliability (Roca et al., 2012). While these are difficult to attain when using human observers as part of the measuring system, a number of procedures were put in place based on accepted practice (O'Donohue, 2010). Definitions of all action variables designed for reliability and independent observations of the same performance were used to maintain objectivity.

For the purpose of this study, expert status was applied when coaches met certain criteria including being recognised as peers as an expert, displaying critical thinking, engaging in a mentoring role, experienced dealing with elite and developmental athletes (Abraham, Collins, & Martindale, 2006; Johnston, Harwood, & Minniti, 2012).Experts were classified as requiring a minimum:

- Five years coaching experience with sub-elite or elite players
- FFA/AFC/UEFA 'A' Licence
- Previous involvement in the FFA elite player pathway

The three chosen experts were all currently working as coaches within elite youth development in Australia. One coach held a Pro-Diploma, a Masters degree in coaching and had nine years coaching experience with elite male and female players at a national level. The second coach held an A Licence, was awaiting assessment on the Pro-Diploma and had five years coaching experience with elite male and female players including National Team players. The third coach held an A licence, a Masters degree in sport development and had 10 years coaching experience with sub-elite and elite male players at a state and national level.

Ethical considerations

Ethics approval was received from the University of Sydney's Human Research committee (Appendix A). All participants were provided with the Participant Information Statement (Appendix B) Consent was gained from the parents or guardians of under-age participants (Appendix C). Consent was gained from the relevant club and coach of the teams that were used for the study (Appendix D).

Participants

Two male teams (N=32) in the game training phase at a club participating in the NSW National Youth Premier League (NYPL) were invited to participate in the study with each team divided into two sub-groups by surname. Before the study began, one player was injured and therefore unable to participate in the initial testing that formed the basis of the study, with the remaining players all able to participate (N=31, age M=14.18, SD=0.55). These comprised a target group (N=16, age=14.21, SD=0.60) that undertook the proposed exercises that form the intervention of this study and a control group (N=15, age M=14.15, SD=0.52) that trained in line with the FFA national curriculum undertaking training sessions designed by the club's Technical Director.

Measures

Video-based decision-making tests

Players undertook a video-simulation based test of decision-making ability similar to those previously used in a number of studies examining decision-making in football (Gabbett et al., 2008; Ward & Williams 2003; Williams et al., 2004; Blomqvist et al., 2005). A pool of 43 video clips was shown to three experts independently, with all three agreeing on the optimal decision to be made by the player when receiving the ball in 23 of these video clips. These 23 clips were then piloted to ascertain reliability by a team in the game training phase in an equivalent training program (N=12, age M=14.36, SD=0.52). Test-retest reliability for each individual video clip was calculated using Cohen's kappa statistic. Twenty video clips recorded a kappa score of >0.80 which is classified as substantial agreement (0.61-0.80; Landis & Koch, 1977). The other three video clips were <0.75 and were excluded from the testing battery.

These 20 clips were then used in the study. The videos showed games from broadcast and aerial views which are readily available (Lorains, 2013) Fourteen of the video clips were edited from an international match filmed from an elevated position on the half way line. The following six clips were from an international match filmed from an elevated position behind one of the goals. In random order, five clips showed defenders, eight showed midfielders and seven showed attackers receiving the ball. Clips depicted the sequence of play directly preceding the targeted player receiving the ball (M= 6.22 secs, SD= 2.92 secs) followed by a freeze frame for 10 seconds at the moment immediately prior to the target player receiving the ball, similar to previous studies (Ward & Williams, 2003; MacMahon, Helsen, Starkes, & Weston, 2006). Players were required to indicate the direction and distance of the first touch they would take (Figures 1 & 2) in each situation using pen and paper in a time-constrained context (Ward & Williams, 2003). An auditory signal was presented before the start of each new clip (Vaeyens et al., 2007).

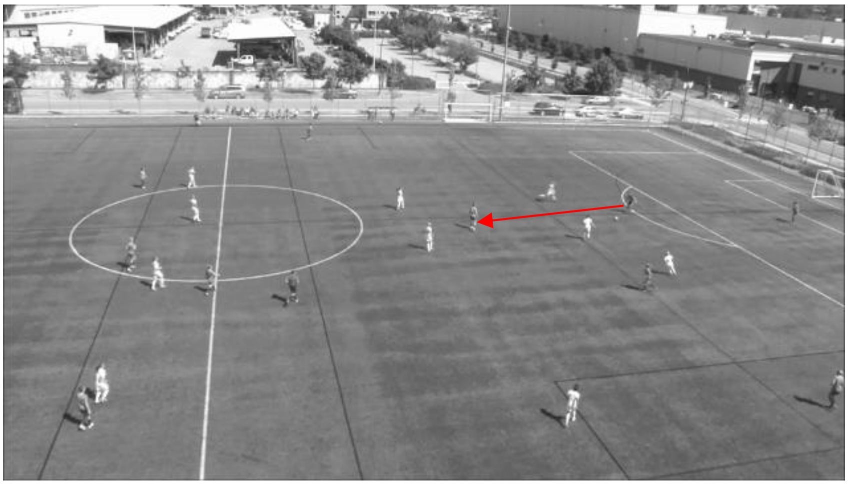

Figure 1. Match filmed from an elevated position on the half way line with correct first touch decision indicated

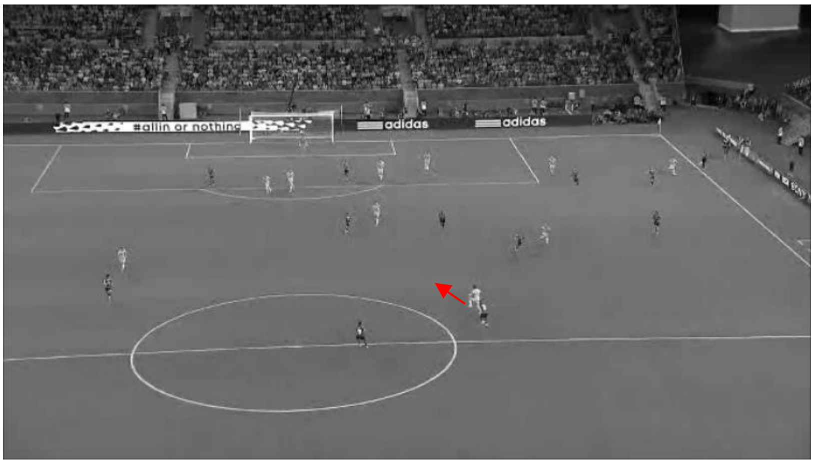

Figure 2. Match filmed from an elevated position above goal with correct first touch decision indicated

Self-assessment Questionnaire

The questionnaire examined players' individual strengths and weaknesses in the areas of awareness, perception, decision-making and first touch. Players were asked to rank on a scale of 1 to 6 their perception of their decision-making skill, using the Likert-style scale used in the Tactical Skills Inventory for Sports (TACSIS; Elferink-Gemser, Visscher, Richart, & Lemmink, 2004) as seen in Table 1. Test-retest reliability of the questionnaire was tested using Pearson's correlation coefficient. Test-retest was r >0.76 indicating substantial correlation (Cohen, 1988).

Table 1. Player Questionnaire completed by players

Items to be answered on a 6-point scale, ranging from 1 = *very poor* to 6 = *excellent* or 1 = *almost never* to 6 = *always*, while comparing oneself with top players in the same age category.	**1**	**2**	**3**	**4**	**5**	**6**
(1) When I receive the ball, my awareness of the space around me is…						
(2) When I receive the ball, my awareness of my teammates positioning is…						
(3) When I receive the ball, I have a clear idea of what I am going to do…						
(4) When I receive the ball, I hear calls from teammates…						
(5) When I receive the ball, my decision-making is…						
(6) When I receive the ball under pressure my first touch creates space for myself…						
(7) When I receive the ball in the final third my first touch creates a scoring opportunity…						
(8) When I receive the ball my first touch creates an opportunity to pass or cross…						
(9) When I receive the ball in space my first touch creates an opportunity to dribble…						
(10) When I receive the ball my first touch takes me forward…						

Game performance

Game performance was assessed by recording three games from each team at pre-, post- and retention. The videos were shot from an elevated position near the half way line in order to provide a 'tactical' view of the field with three quarters of the field showing and all players in frame as much as possible. The video-operator was instructed to record the game from near the sideline in an elevated position to provide an elevated tactical view in which all outfield players were in frame as much as possible. At the conclusion of the match, games were uploaded onto a laptop. Matches were coded using *Longomatch* analysis software to edit the recording into a series of short videos of all individual player first touch actions prior to being distributed to experts. First touch was chosen as the indicator as it represents an important and observable indicator of perception-decision. Each individual player video showed the moment preceding the first touch (5 secs) and after the first touch (2 secs). The criteria for assessing decision-making was adapted from decision-making coding criteria previously used by Gabbett et al. (2008) and Jordet (2005) and is shown in Figure 4.

First Touch: Was the decision to take the first touch appropriate in the context of the given situation? Choose the most appropriate option.

The player's first touch:
(5) created an opportunity to score or to pass to someone with an opportunity to score, or
(4) created an opportunity to dribble into a good area, or created an opportunity to pass or cross to someone in a better position, or
(3) maintained possession without creating an opportunity to score, creating an opportunity to dribble into a good area, or creating an opportunity to pass or cross to someone in a better position, or
(2) took the ball into an area with no purpose (i.e., not going anywhere), or
(1) lost possession, took them into a defender or took the ball out of the field of play

Figure 4. Marking criteria for experts regarding game performance first touch decision analysis

Observations of the effectiveness of the first touch in the match analysis were recorded by experts through an annotation system (See Appendix E). Three expertswere trained to use the annotation system prior to the study and had jointly reviewed a player's actions during an independent match to determine appropriate application of the decision-making coding criterion. Inter-rater reliability for the coaches was calculated using Cohen's kappa statistic showing reliability <.80. One expert was unable to continue to undertake the notational analysis of the matches throughout the study, meaning the analysis of two experts was used. Expertslooked at the intent of the first touch and not the result of its execution. Importantly, the criteria allowed a separation of the cognitive skill of decision-making from the execution of the skill to overcome previous limitations in notational analysis (Lorains, 2013).

Training Intervention

Teams trained three sessions per week for a duration of 75 minutes. The intervention was conducted over a period of five weeks with two 20 minute sessions per week with the target group (cognitive load group) undertaking the intervention in place of the passing practice element of trainings in the game training phase of the FFA National Curriculum (2013). The control group worked with their regular team coaches during this period. Passing practices that involved technical skills with a focus on first touch but minimal decision-making formed the basis of the control group training for this 20-25 minute section of each training. A typical passing practice involved a sequence of passes between players on cones in a pre-determined order set by the coach. Players passed to the next player in the sequence and followed their pass to that cone, with different sequences undertaken each training session (Appendix F).

The target group worked with the researcher who held an FFA B Licence and had over seven years' experience coaching sub-elite and elite level players. Exercises were designed to be used as part of the intervention training with players advancing through a series of progressions across the five-week period. The exercises were designed by the researcher drawing on evidence of trainability of cognition and perception and decision-making in the literature (; Colvin, 2010; Lennemann et al., 2013; Scholz et al., 2009) and based on current trends within coaching (Sinnott, 2011). Players were required to execute movement and first touch ball manipulation skills that are routinely found in a football match while responding to high cognitive effort, visual search and overload tasks through visual, auditory and kinaesthetic cues and instructions. Examples of tasks undertaken during the intervention can be seen in Figure 6. Figure 7 shows the training exercises for the target group.

Figure 6. Multitask training intervention. This figure illustrates some of the cognitive load tasks undertaken by players as part of the intervention.

Visual Search, Perception and Decision Training U14 and U15	WC (Mon)	Wednesday	Monday/Friday
WEEK ONE	22/2	First Touch to gate - Saying colour of gate that touch is to be taken through - Visual stimuli corresponding to colour of gate that touch is to be taken through	Juggling w feet- Responding to number or method of required touches according to auditory stimuli Coordination ladder- - Shuffle - Call colour of ball - Catching ball - Catch and call colour - 1,2,1 - Saying opposite of what is being performed with feet - Clapping/Clicking same as is being done with feet - Clapping/Clicking Opposite of what is being done with feet
WEEK TWO	29/2	First Touch to gate - Saying colour of gate that touch is to be taken through - Visual stimuli corresponding to colour of gate that touch is to be taken through To outside gate - Saying colour of gate that touch is to be taken through - Visual stimuli corresponding to colour of gate that touch is to be taken through	Juggling w feet- Responding to number or method of required touches according to auditory stimuli Coordination ladder- - 1,2,1 - Saying opposite of what is being performed with feet - Clapping/Clicking same as is being done with feet - Clapping/Clicking Opposite of what is being done with feet - 1,2,3,2,1 - Clapping/Clicking same as is being done with feet - Clapping/Clicking Opposite of what is being done with feet
WEEK THREE	7/3	First Touch to gate - Visual stimuli corresponding to colour of gate that touch is to be taken through To outside gate - Visual stimuli corresponding to colour of gate that touch is to be taken through Both gates - Saying colour of gate that touch is to be taken through with visual stimuli to denote inside or outside gate	Juggling w feet- Responding to number or method of required touches according to visual stimuli Coordination ladder- - 1,2,3,2,1 - Clapping/Clicking same as is being done with feet - Clapping/Clicking same as is being done with feet saying colour of visual stimuli - Clapping/Clicking Opposite of what is being done with feet saying colour of visual stimuli - 1,2,3,1,2,3 - Clapping/Clicking same as is being done with feet
WEEK FOUR	14/3	Both gates - Saying colour of gate that touch is to be taken through with visual stimuli to denote inside or outside gate - Visual stimuli corresponding to colour of gate that touch is to be taken through with different visual stimuli to denote inside or outside gate	Juggling w feet- Responding to number or method of required touches according to auditory stimuli Coordination ladder- - 1,2,3,2,1 - Clapping/Clicking same as is being done with feet - Clapping/Clicking Opposite of what is being done with feet saying colour of visual stimuli - Catching and saying colour of ball/ hand being used to catch - 1,2,3,1,2,3 - Clapping/Clicking same as is being done with feet - Clapping/Clicking Opposite of what is being done with feet saying colour of visual stimuli - Catching and saying colour of ball/ hand being used to catch
WEEK FIVE	21/3	Both gates - Two visual stimuli corresponding to colour of gate that touch is to be taken through with different visual stimuli to denote inside or outside gate	Ball fed into feet - Responding to number or method of required touches according to auditory stimuli - Responding to number or method of required touches according to visual stimuli Coordination ladder- - 1,2,3,2,1 - Clapping/Clicking same as is being done with feet saying colour of visual stimuli - Clapping/Clicking Opposite of what is being done with feet saying colour of visual stimuli - 1,2,3,1,2,3 - Clapping/Clicking same as is being done with feet saying colour of visual stimuli - Clapping/Clicking Opposite of what is being done with feet saying colour of visual stimuli - Shuffle - Call colour of ball - Catching ball - Catch and call colour

Figure 7. Schedule of the intervention. This illustrates the tasks undertaken by players in the target group over the five weeks.

Procedure

Questionnaire and video testing were conducted in the club's changing room with one team at a time undertaking the testing. Game performance was filmed during regular season matches at three different grounds. These were done at three time points, pre-, post- and retention. Figure 8 is a flowchart indicating the steps and timings of the project.

Questionnaires were handed out and there was no time limit on players completing them. It was explained that players were comparing themselves to teammates and opponents their age within the NYPL. Players ticked the box 1-6 that correlated to their self-assessed level of expertise in each of the ten areas of decision-making. All players completed the questionnaire within five minutes.

Video decision-making was conducted with the video simulation test being shown on a 50' television screen with players sitting approximately 3-4 metres from the screen. Players involved in the study were shown how to record their decisions using a practice clip (5.02 secs) with the researcher explaining the different options available to them. Using pen and paper in a time-constrained context, players had 10 seconds after the conclusion of each clip to draw the direction and distance of where the first touch should go for each of the 20 chosen clips.

Each of the two teams participating in the study had a match filmed in the week preceding the intervention, the week after the intervention and two weeks post-intervention. No instructions were given to coaches surrounding player roles, time on field and players and coaches were not aware of which specific games were being filmed.

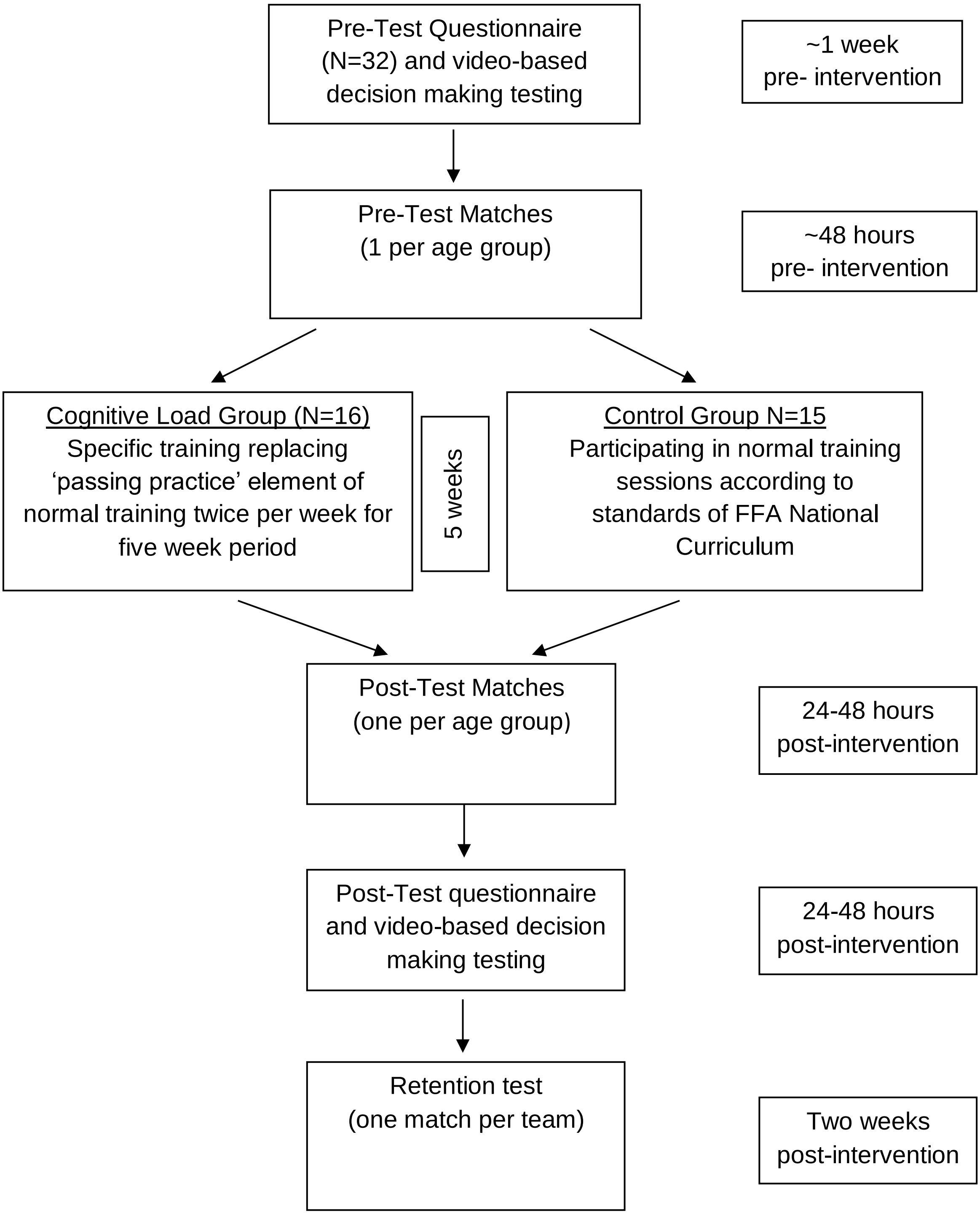

Figure 8. Flowchart of activities during the intervention period.

Data analysis

Analysis of the video decision-making test was done using an annotation system to compare answers to those of the threeexperts. This was repeated each time participants undertook the test. The maximum score for the test was 20, with a correct indication showing the direction and distance of the first touch. A total score was recorded for each player. Results were then compared using SPSS according to whether the player was in the control or target group to determine statistical change pre- and post-intervention and in the retention test.

Analysis of the players' questionnaires was performed by recording player response each time they undertook the test. Results were analysed by whether the player was in the control or target group and by question. Results were compared using SPSS to determine statistical change pre- and post-intervention and in the retention test.

Analysis of game performance was performed by collating the scores of the experts for each player's first touches during the matches. Results were entered into Microsoft excel to determine the average score of each player's first touches and the percentage of their touches that corresponded to each of the marking criteria. Results were compared using SPSS to determine statistical change pre- and post-intervention and in the retention test.

A within-between two group (intervention and control) x three test time (pre-, post- and retention) repeated measures ANOVA was used for the video testing, questionnaire and match analysis. Bonferroni adjustment was applied to all analyses to control for type I error. Follow up pairwise comparisons were used to explore significant main effects. No assumptions were violated for the statistical analyses

CHAPTER FOUR

Results

Results of the three elements of the study were collected at three time points; pre-test, post-test and two weeks after the testing as a retention test. Questionnaires and video testing were done at the same time, with the matches that were analysed filmed within 48 hours of the questionnaires and video tests being completed. Player injuries and absences meant that not all players completed all elements of the testing.

Questionnaire

Results were analysed to determine whether an altered training environment changed players' perceptions of their decision-making ability across 10 aspects of decision-making. Players (N=27) rated themselves using a Likert scale 1-6 with a higher number indicating greater competence. A 2 group (control and intervention) x 3 time (pre-, post-test and retention) repeated measures ANOVA was completed to investigate significant differences between groups of self-assessed decision-making expertise. Table 2 details the results of the two groups across the three time periods.

Results revealed no significant interaction effects and no main group effect in questions 1-7, 9-10. Question 8, 'when I receive the ball my first touch creates an opportunity to pass or cross', showed significance for time across both groups, Wilks Lambda =.725, F (2,24) p= 0.021. A significant difference between post-intervention and retention was found in the target group for Question 8, F (4.013) p = 0.031, ES = 0.25. This suggests players in both groups became increasingly aware over time that their first touch decision does not allow for passing and crossing opportunities as often as they had believed pre-test, with the target group developing this awareness post-intervention.

Table 2. Self-assessment rating of aspects of decision-making

	Control									Intervention								
	Pre-test		Post-test		Retention					Pre-test		Post-test		Retention				
Question	Mean	SD	Mean	SD	Mean	SD	F	p-value	ES	Mean	SD	Mean	SD	Mean	SD	F	p-value	ES
1	3.46	.967	3.69	.480	3.69	.630	.872	.431	.07	4.07	.475	4.07	.616	4.00	.679	.086	.918	.01
2	3.69	.947	3.46	.660	3.62	.506	.351	.707	.03	3.86	.770	3.64	1.008	3.79	.802	.326	.725	.03
3	3.23	.439	3.46	.660	3.54	.967	1.006	.380	.08	3.71	1.139	3.71	.914	3.86	1.027	.184	.833	.02
4	4.31	1.182	4.00	1.155	3.77	.832	2.393	.113	.17	4.07	1.269	4.00	.961	4.07	.829	.093	.912	.01
5	3.54	.660	3.46	.877	3.46	.776	.087	.917	.01	4.00	.784	3.79	.579	3.86	.770	.480	.624	.04
6	3.08	.862	3.38	.870	3.54	.877	2.129	.141	.15	3.57	.756	3.93	.997	3.86	.770	1.297	.292	.10
7	3.31	1.032	3.38	1.446	3.46	1.198	.229	.797	.02	3.71	.852	3.79	.975	3.36	1.082	2.848	.078	.19
8	4.00	.707	4.15	.801	3.85	.555	1.086	.354	.08	4.07	.829	4.21	.699	3.71	.726	4.013	.031	.25
9	3.77	1.013	3.92	1.320	3.46	.776	1.961	.163	.14	4.36	1.151	4.14	.770	4.14	.864	.450	.643	.04
10	4.08	.641	3.85	.689	3.69	.630	1.240	.307	.09	3.79	1.051	3.71	.726	3.79	.699	.059	.943	.01

Video Decision-making

Testing of players' decision-making was conducted using a video-based test. 20 videos were presented to the players with a freeze frame at the end of each video. Players (N=26) indicated where they would take their first touch by marking their decision on a printout of each freeze frame within 10 seconds of the video finishing. They were instructed to indicate both direction and distance of the desired touch. Responses were compared to the optimal decision in each instance based on three experts' agreement on the decision. A 2 group (control and intervention) x 3 time (pre-, post-test and retention) repeated measures ANOVA was completed to investigate significant differences between groups of video-based first touch decision-making. Table 3 details the results across the three time periods.

Table 3. Video-based decision-making accuracy

	Pre-test		Post-test		Retention		F	p-value	Effect Size
	Mean	SD	Mean	SD	Mean	SD			
Control	6.25	3.05	10	2.8	11	2.56	10.729	.001	.48
Intervention	8.14	3.84	11.43	2.82	10.73	2.57	8.503	.002	.43

Results revealed no significant interaction effects and no main group effect. Both groups increased in decision-making with a main effect of time shown, Wilks' Lambda = .319, $F(2,23)$, $p = <0.001$. Pairwise comparisons for the main effect of time corrected using Bonferroni adjustments were conducted. This indicated that there was a significant difference ($p < .01$) between pre-test (M=7.196) and post-test (M=10.714) and between pre-test (M=7.196) and retention test (M=10.750) but not between post- and retention tests. This indicates that on field training, both following the FFA national curriculum and with cognitive load exercises included, transfers to the simulated environment and positively influences decision-making in video-based tests.

Match analysis

Analysis was conducted to determine whether the training intervention led to any significant effect on players' first touch decision-making in matches. Players (N=24) actions were coded using *Longomatch* with each individuals' first touches collated into single player videos. Two experts rated every touch each player took (match one R=3-23, M=10, SD=6.02; match two, R=8-43, M=14.5, SD=8.37; match three; R=4-37, M=18, SD=9.05) on a scale of 1-5 with a higher score indicating a more productive decision in each instance. A 2 group (control and intervention) x 3 time (pre-, post-test and retention) repeated measures ANOVA was completed to investigate significant differences between groups of on field first touch decision-making. Results revealed no significant interaction effects and no main group effect. Table 4 details the results across the three time periods.

Table 4. Mean scores of expert analysis for first touch during matches

	Pre-test		Post-test		Retention		*F*	p-value	Effect Size
	Mean	SD	Mean	SD	Mean	SD			
Control	2.520	.642	2.561	.340	2.391	.360	.738	.490	.07
Intervention	2.933	.578	2.856	.340	2.786	.503	.260	.774	.02

Further, results were examined to determine whether there was any significant effect on the percentage of touches being ranked at a particular score which would indicate a change in specific aspects of player decision-making. A further 2 group (control and intervention) x 3 time (pre-, post-test and retention) repeated measures ANOVA was completed to investigate significant differences between the qualities of individual touches between groups during on field first touch decision-making. Table 5 shows the results of these tests. There was a significant effect for time for rating 1 (touches that lost possession), Wilks' Lambda = 0.661, F (2,21) sig 0.013. Pairwise comparison showed significance between post-test and retention (p = 0.012). There was also a significant effect for time for rating 3 (touches that maintain possession), Wilks' Lambda = 0.702, F (2,21) sig 0.024. Pairwise comparison showed significance between pre-test and post-test (p = 0.021). These results suggest that players were more consistently looking to maintain possession post-test than they had been pre-test.

Table 5. Percentage of total score for individual ranking of first touch by group

	Control									Intervention								
	Pre-test		Post-test		Retention					Pre-test		Post-test		Retention				
Rating	Mean	SD	Mean	SD	Mean	SD	F	p-value	ES	Mean	SD	Mean	SD	Mean	SD	F	p-value	ES
5	.000	.000	.000	.000	.007	.016	.602	.557	.05	.041	.068	.017	.022	.020	.033	1.771	.195	.14
4	.221	.244	.134	.103	.132	.121	.788	.468	.07	.311	.188	.226	.102	.207	.132	.997	.386	.09
3	.303	.098	.442	.094	.378	.171	2.704	.090	.21	.340	.099	.442	.937	.466	.216	2.229	.132	.18
2	.253	.205	.279	.122	.232	.135	.603	.556	.05	.163	.146	.235	.100	.157	.149	1.882	.177	.15
1	.226	.199	.148	.092	.268	.132	4.231	.029	.29	.148	.147	.084	.054	.153	.133	1.548	.236	.13

CHAPTER FIVE

Discussion

Decision-making is a key element of elite performance in football (Baker et al., 2003; Luhtanen, et al., 2004; Memmert et al., 2009). Underpinning good decision-making are perception and cognition. The direction of a players' first touch clearly displays the process of perception-decision-execution. The primary purpose of this study was to assess the effects of an altered training environment focussed on multi-task and cognitive effort training and the effect this would have on players' decision-making. Consequently, the outcome of players' execution was not measured. Players' first touch decision-making was assessed through three measures, a video-based decision-making test, a self-assessment questionnaire and match performance analysis to determine whether there was a significant improvement due to the modified training environment.

Previous studies have used a variety of methods to investigate training and testing of decision-making in football (Ward & Williams 2003; Williams et al., 2004), in other sports (Beilock et al., 2002; Gabbett et al., 2008; Lorains, 2013; Williams et al., 1999;) and in a non-sporting context (Sweller, 2011; Wulf et al., 2001). However, few previous studies had examined both video-based decision-making and on-field decision-making and, consequently, while different training methods had been shown to increase results in video-based tests (Gabbett et al., 2008), there was a gap in the literature concerning the transfer of learning into the match environment. The questionnaire aimed to understand the extent to which a changed training environment impacted players' self-assessment of their perception and decision-making.

This chapter discusses the results obtained and analyses the findings in relation to the literature concerning the three research questions:

1. Will altering elements of the training environment lead to changes of the target groups' self-assessment of their decision-making ability?

2. Does training lead to improved decision-making in a video-based decision-making simulation across both the target and control groups, with the target group demonstrating a greater level of improvement?

3. Does training lead to improved first touch decision-making in the match environment, with the target group significantly improved after specific cognitive load training replacing the traditional passing practice during the intervention period.

This study drew on previous research regarding the design and method of the intervention, along with the measures for assessing players' first touch decision-making using three different measures. The design of the intervention drew from both theory (Scholz et al., 2009; Colvin, 2010) and coaching methodologies currently being practiced in a range of settings (Lennemann et al., 2013; Sinnott, 2011). A number of dual/multi task cognitive load exercises were developed and implemented, replacing the traditional passing practice during two of the three training sessions two teams undertook each week. All the activities incorporated high contextual interference to promote and maintain the link between perception, cognition and action (Broadbent et al., 2015). The exercises were undertaken in a multisensory environment, with players required to respond to visual, auditory and tactile information (Williams et al., 2004), creating an external focus of attention (Wulf et al., 2001) to develop perceptual and cognitive skills. The tasks were a mixture of sport-specific dual task exercises and non-sports specific exercises that it was envisaged would have a transfer effect into the sporting context given the evidence in the literature surrounding development of perceptual-cognitive skills (Jordet, 2005; Jordet, Bloomfield, & Heijmerikx, 2013; Ward & Williams, 2003)

Dual-task and cognitive load exercises were an essential part of the intervention training exercises. Agility ladders were used with a range of exercises requiring players to coordinate the movements of their feet according to a number of different patterns while responding to visual, auditory and kinaesthetic stimuli. Examples included catching different coloured ball while saying the colour being thrown, answering maths equations and identifying the number of fingers being held up by the researcher at the end of the ladder. Agility training has been suggested as a tool for improving cognitive performance in a non-sport specific environment (Lennemann et al., 2013). The dual-task aspect of this element of the training split players' focus of attention to promote perceptual-cognitive skills (Wulf et al., 2001). This reflected an experimental design to determine whether development of non-sports specific dual tasking skills transferred to improved football performance.

Visual search and perception were the other key facet of the intervention training exercises. Coloured first touch gates were used to encourage visual search behaviour. The importance of visual search behaviour in football has been shown with a correlation between search frequency and pass completion rate (Jordet et al., 2013). Players were required to take their first touch through a specified gate based on visual or auditory cues from other players. The ball was passed to players with four coloured gates surrounding them. A teammate would give a visual (for example holding up the colour of the gate they were to take their first touch through) or auditory (calling out the colour of the gate to take their touch through) cue. To avoid automaticity and continually challenge the brain, this included variations such as going through gates of the opposite colour to that being called. Visual search behaviour has been shown to be more advanced in highly skilled football performers (Afonso et al., 2012; Vaeyens et al., 2007).

Players also juggled the football and took first touches of a ball being thrown to them by a partner while responding to external visual or auditory stimuli. An example of this was juggling a ball while calling out how many fingers their partner was holding up. Exercises requiring multitasking of physical elements and visual stimuli, such as juggling, have been shown to change brain matter is areas related to the periphery of vision (Scholz et al., 2009).

Similar to Blomqvist et al. (2005), decision-making in both a video-based decision-making test and in the match environment were assessed in order to ascertain whether decision-making could be improved and whether there was transfer of learning to the match environment. This was important as there has been a scarcity of studies that focus on transfer of perception training to the match environment (Jordet, 2005; Rosalie & Muller, 2012; Williams & Ford, 2013). Importantly, this study separated the cognitive aspect from the execution aspect of decision-making (Lorains, 2013), allowing identification of the specific area requiring particular focus in training.

Players were tested and analysed pre- and post-intervention and two weeks after the intervention in each of the three testing measures. The test two weeks after the intervention was a retention test to determine if there was a learning effect rather than a transient performance improvement. First touch was chosen as the element to test decision-making in this project as, at the elite level, players average three or less touches per time in possession making the first touch vitally important. The focus of the study was on the decision underpinning the first touch, rather than successful execution of the touch. Anecdotal feedback from the experts was that this method of individual player analysis was simple to use in order to analyse performance.

Self-assessment of decision-making

The first aim of this thesis was to investigate differences in players' self-assessment of their decision-making ability over the course of the intervention period and whether an altered training environment had an impact on players' assessment. Questionnaires provide an insight into players' assessment of their own decision-making ability which is both a cognitive and emotional process (Ruiz Perez et al., 2014). Self-perception of decision-making competence changes according to experience and expertise level (Ruiz Perez et al., 2014). The Questionnaire comprised of ten questions regarding players' first touch decision-making with players self-assessing their ability in each domain using a six point Likert scale. Players compared themselves to other players playing in the same level of competition as themselves. It was hypothesised that an alteration in the training environment to incorporate elements specifically targeting cognition and brain training may lead to players having increased self-assessment of their decision-making ability.

The questionnaire comprised questions related to perception-cognition (1,2,4) and to first touch decision-making (3,5,6,7, 8,9,10). In Question 4 (*When I receive the ball I hear calls from teammates*), Question 8 (*When I receive the ball my first touch creates an opportunity to pass or cross)* and Question 9 (*When I receive the ball my first touch creates an opportunity to dribble*), players' mean score was above 4. In Questions 1,2,3,5,6,7 and 10 mean scores were between 3.3 and 4. These were high starting scores across all questions, particularly given the match performance of the teams. It is possible that players' self-assessment reflected their perception of their decision-making expertise compared to their teammates rather than compared to all players at the NYPL level, particularly given that they had only had minimal exposure to opposition teams at the starting point time of the study. It is also possible that players were unable to accurately perceive their own ability, rating themselves according to their 'best' level of performance rather than their 'average' base level of performance (Guenther et al., 2015). Results indicated minimal change across either group in players' self-assessment of their decision-making ability across the period of the study. The limited time frame of this study may be a factor in the scarcity of significant change across the other questions. There may also have been a ceiling effect given the high starting point of the groups. Changes in self-assessment appear able to be recorded more accurately over a longer period, possibly years as was the case in the study by Kannekens et al., (2009) over a period 2001-2008.

The specific focus of the intervention training had led to the hypothesis that there would be an impact on the target group's self-assessment of their ability. The altered training environment of the target group incorporating cognitive load training had limited effect on players' self-assessment of their decision-making ability. However, the target group did show significantly different results in the post-test to retention testing for Question 8, recording lower self-assessment. This was the opposite effect to that which had been hypothesised. The control group did not show the same drop in the period post-test to retention. The lower self-assessment by the target group of their ability to create an opportunity to pass or cross may have been a result of decreased confidence post-intervention. However, given that the match performance indicated no increase in players from either the control or target groups to pass or cross to a player in a better position, this result may indicate that the target group was able to recognise that they had initially over-estimated their own ability in that aspect of decision-making while the control group did not recognise this. Effects of the training intervention on players' self-assessment of their decision-making may take longer than had been hypothesised and may be more accurately evaluated by completing the same questionnaire over a longer period of time.

The minimal difference between the groups suggests cognitive load training does not have a large effect on players' self-assessment of their decision-making in the short term. Beilock et al., (2002) showed differences in performance between participants performing skills when confronted with dual tasks to take focus away from each component of the skill. Training of skills has been shown to be superior when greater cognitive effort is required (Lee et al., 1994). Players' self-assessment suggests they did not identify changes in their own performance that may have been expected given these previous findings as to the effect of dual task training on player performance.

Players self-assessment of their decision-making competence did not alter in the manner that had been hypothesised. While it is possible that players did not feel they had improved in the different aspects of decision-making, it is more likely that the players were unable to accurately assess themselves compared to others in the competition. If players over-estimated their ability at the starting point, there may not have been scope to accurately assess themselves at the end point of the study. The study being undertaken early in the season may not have allowed players to have experienced playing against enough of the other teams and players in the competition to accurately gauge their own decision-making abilities compared to others, particularly at the starting point of the study. This may also explain why the results of Question 8 were lower at the retention test. It is likely that the Playing Form training across the majority of the training sessions had a greater influence on the players' self-assessment of their decision-making than the limited time spent on the differentiated parts of the trainings.

Overall, there was little difference in self-assessment of decision-making over time across either group involved in the study and minimal difference between the groups..

Video-based decision-making

The second aim of the thesis was to investigate whether players increased their decision-making ability over the period of the study and to analyse the impact of the altered training environment using a video-based decision-making test. It was posed as to whether both groups would improve their decision-making given that a large amount of their training was undertaken in Playing Form style training (Ford et al., 2010; Cushion et al., 2012).

The pre-test scores across both groups involved in the study were very low (mean score 7.27 out of 20). This indicated a low base of decision-making preceding the period of the study. This may be due to the players having not trained in the weeks leading up to the intervention due to the holiday period. This is supported by the results showing significant improvement over the five weeks of the intervention but then steadying over the two week retention period.

Results were higher in the video testing (mean score 10.77 out of 20) with a medium effect size indicating an improvement across both the control and target groups after five weeks of training. Both control and target groups increased their scores from pre-test to post-test indicating that both the standard training environment following the four aspects of the FFA model session, and the altered training environment focussing on cognitive load training, had a positive impact on first touch decision-making.

However, it should be noted the scores still indicated a relatively low level of first touch decision-making. This appears to support the notion that elite players are not necessarily exceptional decision makers given the variety of skills and attributes (strength, speed, resilience etc.) required in team sports (Vaeyens et al., 2007). The age and experience level of the players may have had a significant impact on their level of decision-making. In similar studies, Gabbett et al. (2008) found decision accuracy in a video-based test above 80% prior to specific video-based training. However, the study used a team of elite players who were older (mean 18.3) and more experienced than those in the present study. Age and experience appear a key factor in decision-making competence. Blomqvist et al. (2005) conducted a video-based test on players in the same age range as the current study (14-15 years). 17 clips were used of modified 3v3 football. Participants recorded 71.1% correct. The scores in the present study indicate a lower level of decision-making. However, the greater range of variables and potential options in clips from 11v11 matches account for this difference. 11v11 matches were chosen in the present study to increase realism of the test to the match environment (Stoffregen et al., 2003).

The majority of the exercises undertaken by both the control and target groups across the three trainings per week were in Playing Form, including positioning games and small sided games. This may indicate that the current FFA National Curriculum (2013) has a positive effect on developing decision-making in youth footballers in a simulated environment over a five week period, supporting previous suggestions regarding Playing Form training (Cushion et al., 2012; Ford et al., 2010; Williams & Ward, 2007). However, it is also possible that results improved due to a familiarity effect. The results appear to support the findings of Gabbett et al. (2008) regarding the trainability of decision-making, though the results of the present study show that decision-making in a video-based test can be increased without simulation training.

Measuring game understanding in the simulated setting and being able to apply that to the match situation is difficult as this is determined by whether or not the players have the ability to decide what to do and to execute this correctly in response to the game situation that confronts them (Blomqvist et al., 2005). Improvement in a video-based test shows that the knowledge underpinning decision-making has increased, but these tests do not require the same level of perception of the surrounding environment as the match situation. Decision-making in the match environment requires the player to shape their decision based on the perceived information specific to the game environment (Passos et al., 2008). Players' technical ability may impact their decision-making in the game environment. While players may show in a video-based test that they know the best option to take, when confronted with the same situation in a match they may feel incapable of performing the action and therefore take a different option.

The improvement in video-based testing is one indicator of better decision-making, however this form of testing may not accurately reflect the cognitive processes required when playing in a match (Afonso et al., 2012; Farrow & Abernethy, 2003 cited in Lorains, 2013). The decision-making process for a video-based test is different compared to that required on the field, with many of the variables and pressures of the sport withdrawn. Video-based tests do not require the same level of perception as the match situation. Perception requires players to see and hear the environment to detect the useful information (Nyland, 2010). The clips used for testing in the present study were filmed from a tactical viewpoint to show participants in the testing as much of the field as possible. However, this viewpoint does not give players the same perspective they face in a match. Accurately replicating the match environment appears a limitation of all video tests. When clips from a tactical viewpoint are used, participants can assess the peripheral information but are not seeing the same from the perspective faced in a match. When clips depict a first person viewpoint, the image depicts the player's perspective but does not show the peripheral information that players can gather through visual search in the match.

Simulations often fail to involve all the tasks and conditions including peripheral information and the team style and strategy (Jordet, 2005; Williams & Ford, 2013). Despite these limitations, video-based testing remains an easy and effective way of testing decision-making (Lorains, 2013)

The altered training environment of the target group led to no significant differences between the control and target groups in the video decision-making testing. This indicates that training for increased cognition and perception through dual task and cognitive load training does not alter the results achieved in the video-based testing environment in the short term. Participation in Playing Form training during training sessions appears more likely to develop the football knowledge that is a key component of decision-making assessed in video-based tests. The fact that there was no difference between the target and control groups may be due to video-based testing not replicating all the peripheral visual and auditory cues evident in the match environment that dual task and cognitive training is designed to develop.

While the target group did not perform significantly better than the control group, there was no detrimental impact of the intervention. This suggests that the passing practice aspect of a model training session under the FFA curriculum may not be a critical factor in developing decision-making. It also indicates that replacing the passing practice with cognitive load training is equally effective in developing decision-making as the current FFA model when combined with playing form activities. However, further study is required to determine whether there are training methods that will have superior results in developing decision making. While the training intervention focussed on developing cognitive and decision-making skills, it was a Training Form activity. It is possible that decision-making competence in a video-based test is only increased through Playing Form exercises.

It was found that that training leads to better decision-making in a video-based test, however cognitive load training does not alter decision-making in a video-based test.

Match Performance

The final aim of this thesis was to analyse match performance to determine whether there was an increase and transfer of decision-making ability into the match environment and whether cognitive load training had an impact on players' decision-making. It was posed as to whether that there would be a significant impact of altering the training environment on first touch decision-making in the match environment. The game performance analysis was conducted by recording player actions in three games and presenting all the first touches by each player to experts for analysis on a scale of 1-5.

Results indicated no significant difference in the mean scores for either group across the period of the study. The results of the match performance analysis did not reflect the improvement shown in the video decision-making test. This suggests that players on-field decision-making is not markedly changed across a five week period despite undertaking three training sessions per week using primarily Playing Form exercises.

Previous studies have shown improvements in players' ability to undertake football related tasks in the laboratory environment after an intervention with an altered training regime in as little as four weeks (Schollhorn et al., 2004). Their study tested two aspects of football. First, they tested participants' ability to control a ball in minimal space. They also tested their shooting accuracy. 20 exercises were used for each of these two techniques (40 exercises in total per training) trained over a four week period. The control group performed each of the techniques separately in a linear blocked manner. A second group (differentiated blocked group) performed exercises for both techniques together in a blocked order. A third group (differentiated random group) did them in a random order. Significant difference was found between the control group and the two differentiated learning groups. Perceptual training has also been shown to enhance decision-making ability in a video-based test in elite women soccer players (Gabbett et al., 2008). The present study indicates that the same transfer of learning does not occur for decision-making to the match environment over a similar period. Decision-making in the match environment appears far more difficult to influence than skill-execution or video-based decision-making in the short term.

There was however, a statistically significant effect for time for rating 3 (touches that maintain possession), between pre-test and post-test showing that players were attempting to maintain possession throughout the period of the study. Further, there was a significant effect for time for rating 1 (touches that lost possession), between post-test and retention indicating that players were attempting not to lose possession more often post-study. This indicates that players were making less poor decisions leading to losing the ball (rating 1) and were attempting to maintain possession more frequently (rating 3) but were not making a greater number of good decisions leading to better positions (rating 4) or goal scoring chances (rating 5). This shows a small but positive effect of training on in-match decision-making across a five week period. It seems likely that this change in player behaviour would be part of a continuum, whereby players would first minimise the poor decisions being made, then begin to make better decisions. The technical requirements of executing decisions that lead to better positions and goal scoring opportunities may also be more demanding and players may not take these options until they feel they have the technical skills to perform them. The findings support Ford et al., (2010) that a high level of Playing Form training is beneficial to match performance. Given the great number of variables in a match that can affect decision-making (teammates, crowd, match situation, focus on skill execution, position, fatigue etc.) it is perhaps unsurprising that there was not a large increase in players' decisions, particularly in rating 4 and rating 5, across the short period of the study.

It had been anticipated that there would be a difference in the on-field performance of the target group compared to the control group given player' perceptual-cognitive skills are trainable (Williams & Hodges, 2005) and that training of perceptual and cognitive skills should be beneficial for increasing and changing brain matter (Scholz et al., 2009) and for developing game-reading skills (Ward & Williams, 2003). It had been anticipated that performing skills with an external focus of attention requiring players to process multiple pieces of information would improve decision-making (Jackson & Beilock, 2008). It has previously been discussed that skilled performers can assign less attention to a primary task allowing them to direct attention to secondary tasks (Williams et al., 1999). The training intervention was designed to assist players in developing this ability.

There are an increasing number of training programs focussed on 'brain-based', training purported to increase perception and to increase players' decision-making speed (Sinnott, 2011). Tasks used during training activities included speaking in multiple languages and exercises that require players to throw a tennis ball and call out colours while passing the football (Sinnott, 2011). These programs report players increasing perception- both peripheral and split vision- and increased decision-making speed. Interestingly, the results of the present study did not indicate a change in decision-making ability to be the case. Both groups showed equal levels of improvement.

The lack of difference between the two groups can be interpreted in two ways, (a) that neither the passing practice nor the cognitive load intervention are effective in developing decision-making, or (b) that they are both equally effective in doing so. Both the intervention practice and the passing practice being replaced are Training Form exercises, with the intervention focussing on cognitive load and dual task. Playing Form training has been suggested to be more effective in developing decision-making compared to Training Form (Cushion et al., 2012; Ford et al., 2010). It had been hypothesised that cognitive load and dual task activities in Training Form would be effective in developing decision-making. This may not be the case. However, it may be that the effects of altering the training environment cannot be seen over a short time frame. It is also worth considering what constitutes a ‘skilled performer’ (Williams et al., 1999). While the players involved in this study were playing at the top level in their age-groups, their age, technical ability and game understanding may denote that they are not in fact ‘skilled performers’ compared to those in the literature (Williams et al., 1999).

Further, no difference between the two groups indicates that replacing the traditional passing practice with cognitive load and dual task activities makes no difference to match performance over a five week period. Passing practices are generally Training Form exercises which require minimal perception-decision. The cognitive load and dual task exercises that formed the intervention were also Training Form exercises. The key difference was that the cognitive load and dual task exercises required learners to respond to visual, tactile and auditory information espoused as being a key to development of skills to transfer to the game environment (Williams et al., 2004).

Playing Form exercises form a large part of the overall training environment under the National Curriculum (FFA, 2013). The positioning games, game training and training game components are all Playing Form. This appears to have the greatest influence on the outcome of training sessions. There are so many aspects of decision-making including individual strategy (planning ahead), the player’s cognitive map or knowledge base (declarative and procedural knowledge through past experience), tactical knowledge (notions extracted from practice) and resources (motor competencies, concentration level and motivation) (Grehaigne et al., 2001). Training to specifically alter the perceptual-cognitive ability may not have an influence in the short term.

The influence of altered training sessions on decision-making is difficult to assess. The large amount of Playing Form training being undertaken during the training sessions will have influenced players’ decision-making during the time frame. It is possible that the current study was not long enough in duration to allow for new learning pathways to be developed allowing for greater perception and decision-making to be formed (Scholz et al., 2009). It has been reported that the brain undergoes noticeable changes when confronted with complex tasks such as juggling (Hitchins, 2012; Jenerou et al., 2015). However, training exercises incorporating these type of tasks appears not to make a significant difference in the match environment, though there is great difficulty in assessing the effectiveness of altering behaviours such as decision-making with a need to observe changes over time (Williams & Hodges, 2005).

The findings of the game performance analysis in the present study appear to support the criticisms of video-based testing results not completely transferring into the match environment (Farrow & Abernethy, 2003). This may indicate that different processes are involved in players’ decision-making in the simulated environment compared to the match environment (Afonso et al., 2012; Williams & Ericsson, 2005). However, there was some improvement in the scores in match play, though it appears that transfer of learning to the match environment will take longer than the scope of this study. This remains an area that requires further investigation, particularly given the limited duration of the present study. This is particularly the case given the lack of research-based training and testing programs pertaining to perception in the match environment (Jordet, 2005; Jordet et al., 2013). Overall, it is probable that the amount of training time spent on differentiated trainings between the control and target groups, equating to approximately 18% of the weekly training load limited the potential effect of the intervention, particularly given that the rest of the time spent training was in 'best practice' athlete centred Playing Form training with a focus on perception-decision-execution (Cushion et al., 2012; Williams et al., 2004).

There was not a statistically significant positive anser to the research question posed, though further investigation over a longer time period is warranted.

CHAPTER SIX

Conclusion

Summary of key findings

This study provides an important framework for future studies concerning perception and decision-making in football, analysing these key facets of the sport through three measures; questionnaire, video-based decision-making test and game performance analysis. Central to the effectiveness of any intervention is the ability to test whether training translates into the match environment (Rosalie & Muller, 2012).

Findings support previous literature showing decision-making being trainable and that it can be tested through video-based testing. The results illustrate the effectiveness of the current FFA National Curriculum in developing decision-making in the simulated video testing environment over a period of five weeks. The results further indicate that training following the FFA National Curriculum improves decision-making in the match environment with regard to maintaining possession over the same five week period, but does not lead to greater decision-making leading to more scoring opportunities.

Limited difference being found between the control and target group in any of the three measures used in the study points to the traditional passing practice and the cognitive load intervention being equally effective over the five week period. However, there is a need to investigate whether the intervention methods are equally effective to passing practices for developing decision-making in a positive or negative way. Playing Form activities throughout the majority of the training time appears to have had the most significant impact on the development of players' decision-making.

Though not measured in the study, there was an observable increase in the ability of players to successfully undertake the tasks involved in the intervention across the five week period. Player feedback also suggested that they enjoyed and felt challenged by the altered training environment. Given that there was no negative impact of the intervention training strategy on any of the three measures involved in the study indicates that further investigation is warranted and that it represents a viable alternative to traditional passing practices.

Practical implications

This study has several implications for training and testing decision-making in youth footballers. Of particular interest is that changing aspects of the training environment appears to have very little impact on players self-assessed decision-making ability, performance in a video-based test or performance in the match environment. This may be due to the significant amount of time spent in Playing Form activities in the remainder of the training time. Each of the testing measures employed in this study give an insight into the development of decision-making in youth football.

Firstly, the limited change in players' self-assessed decision-making expertise across the period of the study is of considerable interest. Across a period in which both groups improved their decision-making in a video-based test and made less poor decisions in the match environment, there was no positive change in players' self-assessment of their cognitive-perceptual or decision-making competence.

Secondly, the significant impact of training on players' video-based decision-making aptitude indicates that training under the FFA National curriculum increases players' decision-making outside the match environment.

Thirdly, the relatively small differences observed in players' decision-making in the match environment indicates that transfer of learning does not take place as quickly into the match environment. This is an important distinction and shows the need to test transfer of learning to the match setting to accurately gauge learning.

Finally, while results regarding the impact of altering the training environment to include cognitive load training were largely inconclusive, the fact that no negative impact was shown indicates that cognitive load training is at least as effective as traditional passing practices in developing decision-making.

Limitations

The organic nature of the study, wherein players were analysed in the match environment, rather than in a simulated training environment, led to some limitations of the study which may have affected the results. Some players missed trainings and/or games through injury or illness. Many players were used in different positions or roles both during and between games. The different strengths and styles of opposition teams may also have impacted upon the ability of players to display greater decision-making ability.

Despite these limitations, it was decided that the importance of being able to assess the transfer of training to the match environment was of key concern and this remains a significant consideration in any analysis of decision-making. A larger sample size over a longer period would be valuable in gaining a true reflection of the impact of cognitive load training on perception and decision-making in the match environment and on players' self-assessment of their competence.

Future Research

This thesis provides a framework for analysing decision-making in youth football across three key measures to assess the impact of an altered training environment based on cognitive load training exercises. As this was an exploratory study with a limited sample over a short time period, further research is needed to determine the impact of cognitive load and dual-task training on decision-making. In order to gain a greater understanding of the impact of this altered training environment, future studies could broaden the focus of analysis to a wider number of aspects of decision-making in the match environment outside first touch, including off ball movement and defensive actions. Impact of cognitive load training on execution of football actions could also be investigated. Future research should also continue to assess the impact of training interventions by analysing transfer of learning to the on field match environment as the this is the most important consideration in any training program.

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Appendix

Appendix A- Ethics Approval

THE UNIVERSITY OF SYDNEY

Research Integrity
Human Research Ethics Committee

Wednesday, 2 December 2015

Assoc Prof Donna O'Connor
Fac Ed & Soc Wk - Research; Faculty of Education & Social Work
Email: donna.oconnor@sydney.edu.au

Dear Donna

I am pleased to inform you that the University of Sydney Human Research Ethics Committee (HREC) has approved your project entitled **"An examination into the effects of specific and targeted cognitive training on perception and decision making in football"**.

Details of the approval are as follows:

Project No.: **2015/894**

Approval Date: **30 November 2015**

First Annual Report Due: **30 November 2016**

Authorised Personnel: **O'Connor Donna; Taylor Andrew;**

Documents Approved:

Date	Type	Document
09/10/2015	Questionnaires/Surveys	Decision Making Questionnaire
26/10/2015	Other Instruments/Tools	Intervention Overview
29/11/2015	Participant Info Statement	PIS Parent Amended Final
29/11/2015	Participant Info Statement	PIS Participant Amended Final
29/11/2015	Participant Consent Form	Consent Form Amended Final
29/11/2015	Participant Consent Form	Consent Form Parent Highlighted

HREC approval is valid for four (4) years from the approval date stated in this letter and is granted pending the following conditions being met:

Condition/s of Approval

- Continuing compliance with the National Statement on Ethical Conduct in Research Involving Humans.
- Provision of an annual report on this research to the Human Research Ethics Committee from the approval date and at the completion of the study. Failure to submit reports will result in withdrawal of ethics approval for the project.
- All serious and unexpected adverse events should be reported to the HREC within 72 hours.
- All unforeseen events that might affect continued ethical acceptability of the project should be reported to the HREC as soon as possible.

Research Integrity
Research Portfolio
Level 6, Jane Foss Russell
The University of Sydney
NSW 2006 Australia

T +61 2 8627 8111
F +61 2 8627 8177
E ro.humanethics@sydney.edu.au
sydney.edu.au

ABN 15 211 513 464
CRICOS 00026A

THE UNIVERSITY OF SYDNEY

- Any changes to the project including changes to research personnel must be approved by the HREC before the research project can proceed.

- Note that for student research projects, a copy of this letter must be included in the candidate's thesis.

Chief Investigator / Supervisor's responsibilities:

1. You must retain copies of all signed Consent Forms (if applicable) and provide these to the HREC on request.

2. It is your responsibility to provide a copy of this letter to any internal/external granting agencies if requested.

Please do not hesitate to contact Research Integrity (Human Ethics) should you require further information or clarification.

Yours sincerely

Glen Davis
E

Professor Glen Davis
Chair
Human Research Ethics Committee

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007), NHMRC and Universities Australia Australian Code for the Responsible Conduct of Research (2007) and the CPMP/ICH Note for Guidance on Good Clinical Practice.

Appendix B- Participant Information Statement

PARTICIPANT INFORMATION STATEMENT

Title: An examination into the effects of specific and targeted cognitive training on perception and decision-making in football

(1) What is this study about?

You are invited to participate in a research study about training perception and decision-making when receiving the ball during a football match.
This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the study. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about. So it's up to you whether you wish to take part or not.

By agreeing to take part in this study you are telling us that you:
✓ Understand what you have read
✓ Agree to take part in the research study as outlined below
✓ Agree to the use of your personal information as described
You will be given a copy of this Participant Information Statement to keep.

(2) Who is running the study?

Andrew Taylor is conducting this study as the basis for the degree of Masters of Education at The University of Sydney. This will take place under the supervision of Associate Professor Donna O'Connor. Andrew Taylor is also a part-time coach at the club but does not work with the teams or players involved in this study.

(3) What will the study involve?

The study involves your team participating in a five week training program that modifies the current coaching environment. Prior to the training program, the team will complete a brief questionnaire and video based test related to first touch decision-making. You will then be randomly assigned to either a control or study group. You will not be able to choose or change which group you are assigned to. During the five week program the team will participate in their regularly scheduled trainings and matches. The researcher will be conducting some activities that may improve perception and decision-making with the study group. This will involve replacing the passing practice element of the training session (approximately 20 minutes) with tasks such as coordination ladders and juggling designed to improve cognitive ability and peripheral awareness before joining back with the rest of the team for the remainder of the training session. At the conclusion of the five week program, the team will complete the questionnaire and video based test again for comparison with pre-training values. A training match before and after the study period will also be video recorded.

(4) How much time will the study take?

In total, your participation will result in approximately 11 hours to complete the study. Of this time, 10 hours will be your normal training sessions. For the additional one hour, the pre and post testing sessions will take approximately 30 minutes each.

(5) Do I have to be in the study? Can I withdraw from the study once I've started?

Being in this study is completely voluntary and you do not have to take part. Your decision whether or not to participate will not affect your/their relationship with the researchers or anyone else at the University of Sydney or North Shore Mariners, now or in the future and will have no impact on your game-play. If you decide not to be in the study you will continue to train as normal with your team as part of the control group and your actions during matches will not be analysed.

If you decide to take part in the study and then change your mind later you are free to withdraw from the study at any time. This can be done by contacting Andrew Taylor. There are no negative consequences of withdrawing from the study.

(6) Are there any risks or costs associated with being in the study?

We do not expect that there will be any risks or costs associated with taking part in this study for you.

(7) Are there any benefits associated with being in the study?

We cannot guarantee you will receive any direct benefits from being in the study. However, the results of this study will be used to develop coach education strategies. You should then receive a consequential benefit through improved coaching strategies.

(8) Can I tell other people about the study?

Yes.

(9) What will happen to information that is collected during the study?

By providing your consent, you are agreeing to us collecting personal information about you for the purposes of this research study. Their personal information will only be used for the purposes outlined in this Participant Information Statement, unless you consent otherwise.

Your information will be stored securely and their identity/information will be kept strictly confidential, except as required by law. Study findings may be published. Although every effort will be made to protect your identity, there is a risk that they might be identifiable in these publications due to the nature of the study and/or the results.

We will keep the information we collect for this study, and we may use it in future projects. By providing your consent you are allowing us to use your information in future projects. We don't know at this stage what these other projects will involve. We will seek ethical approval before using the information in these future projects.

(10) What if we would like further information about the study?

When you have read this information, Andrew Taylor will be available to discuss it with you further and answer any questions you may have.
If you would like to know more at any stage during the study, please contact:

Andrew Taylor, Faculty of Education and Social Work at the University of Sydney.
Contact details: Telephone: 0412555954, E-mail: atay9592@uni.sydney.edu.au

Donna O'Connor, Faculty of Education and Social Work at the University of Sydney.
Contact details: Telephone: 9351 6343, E-mail: donna.oconnor@sydney.edu.au

If you (or your parents) are concerned about the way this study is being conducted or wish to make a complaint to someone independent from the study, please contact the university using the details outlined below. Please quote the study title and protocol number.

The Manager, Ethics Administration, University of Sydney:

- **Telephone:** +61 2 8627 8176
- **Email:** ro.humanethics@sydney.edu.au
- **Fax:** +61 2 8627 8177 (Facsimile)

Appendix C- Parental Consent Form

PARENT (OR GUARDIAN) AND CHILD CONSENT FORM

I, ... agree to permit .... who is aged .... years, to participate in the research project –

An examination into the effects of specific and targeted cognitive training on perception and decision-making in football

In giving my consent I acknowledge that:

1. *I have read the Information Statement and the time involved for my son's/daughter's participation in the project. The researcher/s have given me the opportunity to discuss the information and ask any questions I have about the project and they have been answered to my satisfaction.*
2. *I understand that being in this study is completely voluntary – I am not under any obligation to consent to my son/daughter's participation*.
3. I understand that I can withdraw my son/daughter from the study at any time without prejudice to my or my son/daughter's relationship with the researchers, the University of Sydney or the football club now or in the future.
4. I agree that research data gathered from the results of the study may be presented in a conference presentation or published in an academic journal provided that neither my son/daughter nor I can be identified.
5. I understand that if I have any questions relating to my son/daughter's participation in this research I may contact the researcher/s who will be happy to answer them.
6. I acknowledge receipt of the Information Statement.
7. I have explained to my son/daughter what this research involves and the time involved for participation
8. I consent to non-identifiable data being used in the future YES ☐ NO ☐
9. *I would like to receive feedback: YES ☐ NO ☐*

If you answered YES to the "Receiving Feedback", please provide your address or email:

Email: ____

....

Signature of Parent/Guardian Signature of participant

....

Please PRINT name Please PRINT name

Appendix D- Club Consent

October 20, 2015

MARINERS

NORTH SHORE
MARINERS

North Shore Mariners Football Club
Letter of Support

To the Research Ethics Committee,

On behalf of the North Shore Mariners Football Club, we support the research to be conducted by Andrew Taylor as part of his Masters in Education thesis at the University of Sydney.

We are aware that the study will involve providing access to players, fields and resources and that Andrew Taylor will be working directly with players as part of a training intervention examining perception and decision making.

Video recording of training and games is already a standard aspect of our program.

Regards,

Wayne O'Sullivan
Academy Director
North Shore Mariners

Appendix E- Expert Notation

Player:

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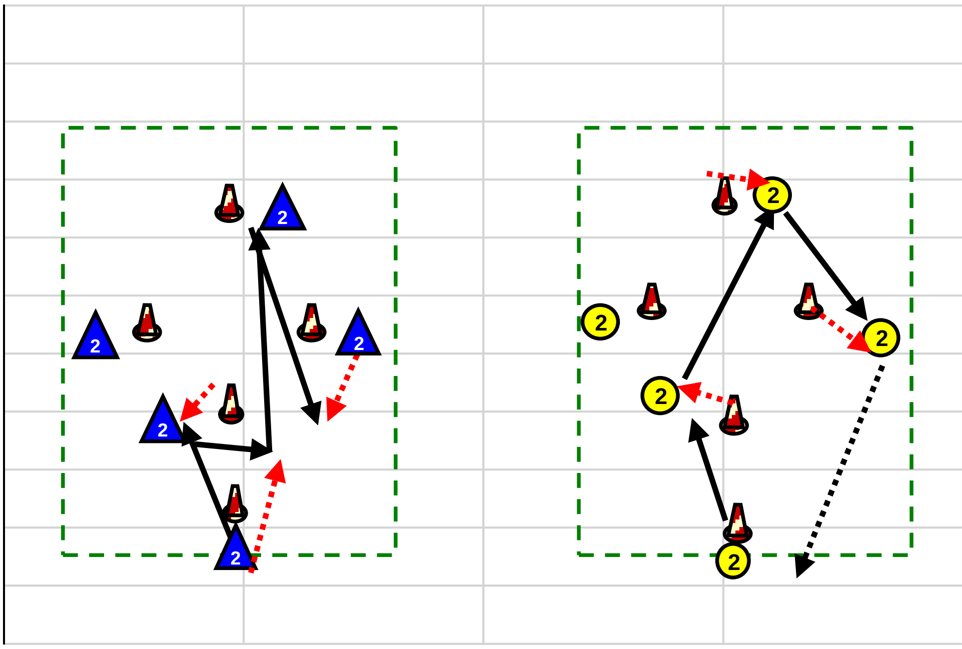
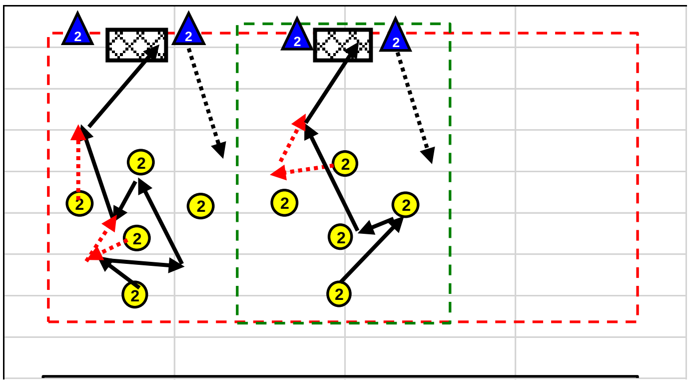
Appendix F- Passing Practices



Weeks 1 & 3



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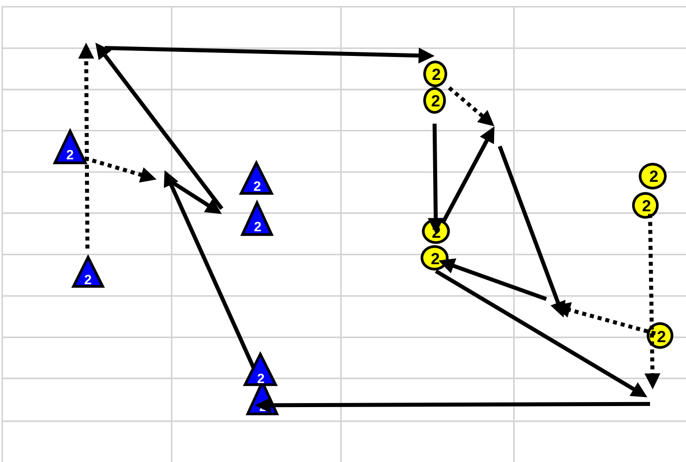

Week 5