Reading the game

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General introduction

In many complex dynamic motor tasks in domains such as sport, aviation, or the military, and in every-day tasks like driving a car or crossing a street, the ability to pick up visual information and to select and execute an appropriate action is key to high-level performance (Williams & Ericsson, 2005; Williams, Ford, Eccles, & Ward, 2011). Especially sports offer a unique, dynamic, and time-constrained environment in which expertise can be examined. Better understanding of the required skills and the underlying processes that discriminate individuals with varying levels of performance, can facilitate the development of effective practice and instruction methods, and the processes of talent identification and development.

In team sports, like soccer and basketball, performance is multifactorial and depends on physiological, technical, psychological and tactical skills (Reilly, Williams, Nevill, & Franks, 2000). For example, soccer players must pick up information from the ball, teammates and opponents to decide upon an appropriate course of action while taking into account the action constraints (e.g., technical ability, physical capacity) and current objectives (e.g., strategy; Williams, 2000). These decisions are often made under pressure, as opponents try to reduce the time and space available to perform. Players therefore need to quickly recognize the pattern of play, anticipate future events, and make fast and accurate decisions. This ability to 'read the game' is an important factor of team sport performance and it distinguishes skilled from less skilled players (Williams, 2000). Tactical expertise means choosing the correct action at the correct moment and performing that course of action efficiently and consistently throughout a match (Baker, Cote, & Abernethy, 2003; Grehaigne, Godbout, & Bouthier, 2001). Tactical skills should not be confused with strategy. "Strategy refers to all plans, principles of play, or action guidelines decided upon before a match in order to organize the activity of the team and the players during the game" (Grehaigne, Godbout, & Bouthier, 1999, p. 166), while tactical skills refer to all spontaneous actions voluntarily executed by the players during the game in order to adapt to the immediate requirements of the dynamic and ever-changing environment (Grehaigne et al., 1999).

In 1991 Ericsson and Smith proposed the expert performance approach as a framework to study how experts perform or learn skills (Williams, Fawver, & Hodges, 2017). This approach consists of three stages (Figure 1.1). In the first stage, the aim is to capture expert performance in a reliable and objective manner and to identify the component skills that discriminate the skilled from the less-skilled performers. This can be achieved under controlled conditions in the laboratory or using appropriate field tests. The expert-novice paradigm is often used in this first stage to examine perceptual-cognitive skills of performers in lab-settings. In the second stage, the aim is to determine the processes and mechanisms that underlie expert performance using process-tracing measures such as eye-movement recordings, film occlusion, and verbal reports. Knowledge of the underlying processes and mechanisms can facilitate understanding of the factors that contribute to expert performance and how experts perform better than novices. The aim of the final stage is to examine the acquisition of the identified characteristics of expertise. This can be achieved using learning studies, training interventions, and retrospective training history profiles. In this thesis, the expert performance approach has been applied to gain a better understanding of tactical skills in team sports; all stages are represented in the studies reported. Chapters 2-5 focus on video-based tests of perceptual-cognitive skill and specific field tests in order to capture expert performance reliably and objectively. To identify underlying mechanisms, eye-movement recordings are used in Chapter 2, 4, and 5. And the final experimental chapter, Chapter 6, contains a learning study to examine how expertise can be developed. In the current chapter, I will elaborate on the key topics of this thesis: perceptual-cognitive skills, gaze behaviour, measuring performance, and the role of feedback in improving performance. This chapter ends with an overview of the study aims that are addressed in the next chapters.

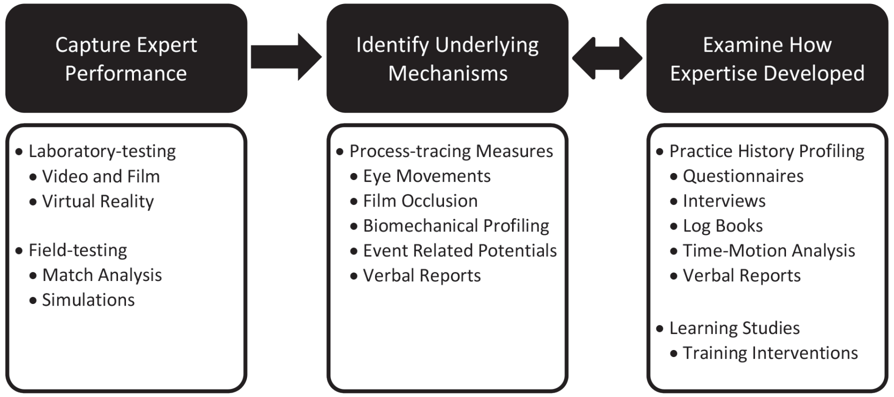

Figure 1.1. The expert performance approach proposed by Ericsson and Smith (1991). Adopted from Williams and Ericsson (2005).

Perceptual-cognitive skills

It has been well established that skilled athletes possess better perceptual-cognitive skills than their less-skilled counterparts. Perceptual-cognitive skill is the ability to identify and acquire perceptual information, for integration with existing knowledge, to facilitate the selection of an appropriate response to be performed (e.g., Williams & Ericsson, 2005; Williams & Ford, 2008). Perceptual-cognitive skills include anticipation, pattern recall, and decision making. Although such skills are likely to be seamlessly integrated during high-level performance, the majority of research to date has largely examined performance on tests of perceptual-cognitive skill independently. Therefore, each of these skills will be discussed in turn.

Anticipation

Anticipation is the ability to predict the outcome of another person's action on the basis of the pickup of advance visual cues that arise from the postural orientation before a key event such as foot-ball contact in soccer or racquet-ball contact in tennis (e.g., Abernethy & Russell, 1987b; Jones & Miles, 1978; Savelsbergh, Williams, Van der Kamp, & Ward, 2002; Williams & Ward, 2007). The skilled performer's ability to use advance information is one of the earliest and most robust findings in the perceptual-cognitive skill literature (Williams & Ward, 2007), and is essential in fast ball sports, because the speed of play and ball velocity dictate that response actions must often be initiated in advance of the completion of the opponent's action (Abernethy, 1987). For example, a soccer penalty kick shot at a speed of 80 km/h, provides the goalkeeper with just over half a second to respond. Taking into account the reaction and movement time, the goalkeeper simply does not have enough time to reach the corner of the goal to stop the ball when he waits for the ball-flight information (Van der Kamp & Savelsbergh, 2010). Therefore, the goalkeeper has to use information from the penalty taker's postural orientation to anticipate the direction of the shot.

The ability to anticipate has typically been assessed using a temporal occlusion paradigm. This technique involves presenting participants with video clips of opponents' actions that vary in the amount of advance and ball-flight information, and requesting the participants to determine what happened next. Abernethy and Russell pioneered the work on anticipation in the late 1980s (e.g., Abernethy, 1990; Abernethy & Russell, 1987a; Abernethy & Russell, 1987b). They examined anticipatory skills of expert and novice badminton and squash players using the temporal occlusion paradigm, and found that experts were superior in predicting the direction of the strokes as they were able to pick up earlier advance information than novices. Expertise-related differences in anticipation skill were found in a number of sports, including tennis (Jones & Miles, 1978), volleyball (Cañal-Bruland, Mooren, & Savelsbergh, 2011; Starkes, Edwards, Dissanayake, & Dunn, 1995), field hockey (Starkes, 1987), and soccer (Savelsbergh, Haans, Kooijman, & van Kampen, 2010; Savelsbergh, Onrust, Rouwenhorst, & Van Der Kamp, 2006; Savelsbergh, Van der Kamp, Williams, & Ward, 2005; Savelsbergh et al., 2002; Ward & Williams, 2003; Williams & Burwitz, 1993; Williams, Davids, Burwitz, & Williams, 1994). Although most research on anticipation in soccer has been conducted using penalty kicks, the assumption is that out-field players rely on similar sources of information when trying to anticipate the direction of an opponent's pass (Williams, 2000). For example, Williams et al. (1994) required experienced and inexperienced soccer players to watch video clips of open-play soccer situations. When the ball was passed to a highlighted player, the participants had to identify as quickly and accurately as possible the destination of the pass made by this highlighted player. The results showed that the experienced players demonstrated superior anticipatory performance.

Pattern recall

Pattern recall or pattern recognition is the ability to recall or recognize previously seen patterns of play (e.g., Allard, Graham, & Paarsalu, 1980; Gorman, Abernethy, & Farrow, 2012). This ability has typically been assessed by showing participants static or dynamic footage of game situations for a very short period of time. Directly afterwards, participants are required to recall the position of each player as accurately as possible. Recall accuracy has been determined by the degree of correspondence between the presented and the reconstructed player positions.

Early research on pattern recall skills was conducted by De Groot (1965) and by Chase and Simon (1973) and focused on the differences in the reproduction of chess positions between chess masters and less-skilled players. After viewing chess configurations for a couple of seconds, chess masters were better able to recall the positions of the pieces than the less-skilled players, but only when structured chess configurations were displayed. When the pieces were randomly positioned on the board, the master players could not recall them better than the weaker players. The superior performance of the chess masters therefore seems not to depend on enhanced short-term memory, but on the ability to perceive structure in the chess configuration and encode this in chunks of several pieces, thereby circumventing the limitations of short-term memory (Chase & Simon, 1973). Following these initial studies, the pattern recall paradigm has also been used to examine the underlying skills of performance in team sports (Allard et al., 1980; Borgeaud & Abernethy, 1987; Gorman, Abernethy, & Farrow, 2011; Gorman et al., 2012; Gorman, Abernethy, & Farrow, 2013a, 2013b; Williams, Davids, Burwitz, & Williams, 1993). For example, Williams et al. (1993) studied pattern recall skills of experienced and inexperienced soccer players. After viewing video clips of structured and unstructured soccer game situations, the participants were required to recall the positions of the players as accurately as possible by positioning schematic representations of players on a computer-generated image of a soccer field using the mouse. The findings showed that the experienced soccer players recalled the positions of the players more accurately than the novices, but again only for the structured game situations. Comparable findings have been found, among others, in basketball (Allard et al., 1980; Gorman et al., 2011, 2012, 2013a, 2013b), volleyball (Allard & Starkes, 1980; Borgeaud & Abernethy, 1987), rugby union (Farrow, McCrae, Gross, & Abernethy, 2010), and field hockey (Abernethy, Baker, & Cote, 2005).

Since the capability to recall patterns of play is rarely, if ever, directly required in team sports, a key question is whether the significant differences in pattern recall accuracy between skilled and less-skilled players serve any functional purpose (Gorman et al., 2012; Williams & Davids, 1995). The early work of De Groot (1965) showed that when the master chess players made mistakes in recalling the structured chess configurations, they incorrectly placed the pieces in positions that were possible subsequent moves. Also in team sports, it has been shown that players bias their recall more on the (anticipated) next likely state of the pattern than the final image of the pattern actually seen (e.g., Didierjean & Marmeche, 2005; Gorman et al., 2011, 2012). This suggests that pattern recall serves an anticipatory function; the ability to recall the positions of players in team sports assists players in predicting the next likely situation and thereby helps to decide upon the best response (Farrow et al., 2010; Gorman et al., 2012, 2013b; Williams & Davids, 1995).

Decision making

Decision-making is the ability to select the best possible option from a variety of alternatives (e.g., Helsen & Pauwels, 1993; Vaeyens, Lenoir, Williams, Mazyn, & Philippaerts, 2007), and has been suggested to be the most successful method of evaluating expert performance (De Groot, 1965). This ability has typically been assessed using video-based tests. Participants watch video-clips of game situations that are occluded at a decisive moment in the game. The participants are then required to indicate the best option for the player in possession of the ball (e.g., pass, shoot or dribble). The correct response for each game situation had previously been determined by a panel of expert coaches.

Using this design, experienced players were found to make faster and more accurate decisions than less-experienced players in, among others, basketball (Bard & Fleury, 1981; Gorman, Abernethy, & Farrow, 2015; Ryu, Abernethy, Mann, & Poolton, 2015), field hockey (Starkes & Deakin, 1984), and soccer (Helsen & Pauwels, 1993; Vaeyens, Lenoir, Williams, & Philippaerts, 2007). For example, Vaeyens, Lenoir, Williams, and Philippaerts (2007) studied decision-making skills of soccer players varying in experience and skill level. The participants were presented with video clips of offensive game situations. As soon as a previously indicated player received the ball, the video footage was occluded and the participants were required to indicate what the player with the ball should do: dribble, pass or shoot at goal. Results showed that the high-skilled players reacted faster and more accurate than the less-skilled players.

Although decision making is an important component of expert performance, it would be incorrect to assume that all experts are good decision makers. It is typical of team sports that weaknesses on certain components of performance (e.g., decision making) may be compensated by strengths on others (e.g., speed and agility; Williams & Ericsson, 2005; Williams & Reilly, 2000). Instead of the customarily used expert-novice paradigm, a more worthwhile comparison, therefore, would be to examine whether within a group of elite athletes the ones who are successful in making tactical decisions can be discriminated from those who are less successful in such situations (Williams & Ericsson, 2005; Williams & Ward, 2007). An important question to answer is how successful decisions are made? Knowledge of the underlying processes and mechanisms can facilitate our understanding of expert tactical decision making. One possible way to gain insight into this is through the examination of gaze behaviour (Williams & Ericsson, 2005).

Gaze behaviour

In team sports, players need vision to obtain information from the ball, the goal, and the positions of teammates and opponents. This does not mean that other sources of sensory information are not being used, but visual information is the source upon which we rely most (Williams, Davids, & Williams, 1999). To pick up visual information, light enters the eye through the pupil and arrives at the retina. The retina converts light into energy that results into neural activation. Small and rapid eye movements are needed to shift informative areas of the display from the periphery of the visual retina, where resolution is poor, to the fovea. The fovea takes up around 2 degrees of the central area of the retina and it receives the clearest and sharpest image (Williams et al., 1999). To view moving objects, one therefore must continually adjust the positioning of the fovea by moving the eyes and or the head. A fixation occurs when gaze is held on a location within 3° of visual angle for 100 ms or longer (Vickers, 2007). The 100 ms is the minimum amount of time needed to recognize or become aware of the stimuli. Pursuit tracking occurs when a moving object is being followed, such as a ball or a person. Gaze is then stabilized on the moving object and the 100 ms threshold is also used. As sport is very dynamic, fixations and pursuit tracking are often taken together. The duration of the fixation/pursuit tracking has been assumed to indicate the relative importance of that area to the observer (Williams et al., 1999). To quickly scan from one location to another, for example from a defender to a teammate, saccadic eye movements are used. A saccade is a rapid eye movement from one fixated or tracked location to another, during which visual information cannot be picked up. Theoretically, because of the suppression of information during saccadic eye movements, a visual search strategy with fewer but longer fixations/tracking and consequently fewer saccades is assumed to be more effective (Williams et al., 1994; Williams et al., 1999).

Registration of visual search strategies (or gaze behaviour) can be achieved using eye tracking technology. Most popular eye tracking devices in sports are corneal-reflection systems, which record the participant's eye movements on video using cameras mounted in glasses, as shown in Figure 1.2. The corneal-reflection method comprises that the reflection of a beam of light on the cornea and the centre of the pupil are determined by the system. The position of the corneal-reflection remains constant relative to the glasses, while the centre of the pupil moves whenever the eyes moves. The system determines the point of gaze by measuring the differences between the corneal reflection and the centre of the pupil. A marker highlighting the point of gaze is superimposed on the video images of the scene camera, which is also mounted on the glasses. In this way a video is provided of what the participant is looking at (see Figure 1.3).

There are, however, some substantial limitations of using eye registration techniques to gain insight into visual perception (Mann, Farrow, Shuttleworth, & Hopwood, 2009; Ryu, Abernethy, Mann, Poolton, & Gorman, 2013; Williams & Davids, 1998; Williams, Janelle, & Davids, 2004). Visual fixations are not directly related to information extraction; it is possible to fixate a location without picking up information (Williams et al., 2004), the difference between 'looking' and 'seeing'. It is also possible to look at one point but pick up information from the periphery. For example a team sports player may fixate on a defender, but may be picking up information from the periphery regarding the movements of a teammate to perform a 'no-look' pass. Such strategies are often encouraged by coaches as deception strategies; it makes it difficult for an opponent to anticipate the destination of a pass. Recent studies have shown that peripheral vision is of eminent importance for decision making in complex and dynamic situations (Ryu et al., 2015; Ryu et al., 2013).

The way athletes pick up visual information has generated significant interest in recent years. Early research on vision in sports focused on differences in visual 'hardware' between skilled and less-skilled performers (Williams, 2000). Various physical and optometric properties of the visual system were measured, such as static and dynamic acuity, depth perception, colour vision, and peripheral visual range. The current consensus is that compared to less-skilled athletes, skilled athletes do not have enhanced visual hardware' (Helsen & Starkes, 1999; Ward & Williams, 2003; Williams, 2000; Williams et al., 1999), but rather enhanced visual 'software'. For effective performance in sports, it is essential that players focus their attention at the most relevant sources of information at the appropriate time; knowing 'where' and 'when' to look is important. One of the earliest studies examining visual search behaviour in soccer was undertaken by Helsen and Pauwels (1993). They examined the visual search strategies of expert and novice players when presented with video clips of real game situations that stopped at a specific moment in the development of the play. The participants had to respond to the situation by shooting at the goal, dribbling around an opponent, or passing to a teammate, while wearing an eye tracking device. The number of fixations per second, fixation duration, and fixation location were identified, which are traditionally used dependent variables in determining visual search strategies. The experts showed faster and more accurate decision making compared to the novices, but also scanned the information with fewer fixations of longer duration and looked more to the teammates and free space while the novices looked more to the attackers, the goal, and the ball. The more efficient visual search strategy of experts, involving fewer fixations of longer duration, compared to novices has often been reported (see Mann, Williams, Ward, & Janelle, 2007 for a meta-analysis), but appears to be very context specific (Gorman et al., 2015; North, Williams, Hodges, Ward, & Ericsson, 2009; Roca, Ford, McRobert, & Williams, 2013; Vaeyens, Lenoir, Williams, Mazyn, et al., 2007; Williams & Davids, 1998).

Figure 1.2. Basketball player wearing an eye tracking device (Photo: Mark Sassen).

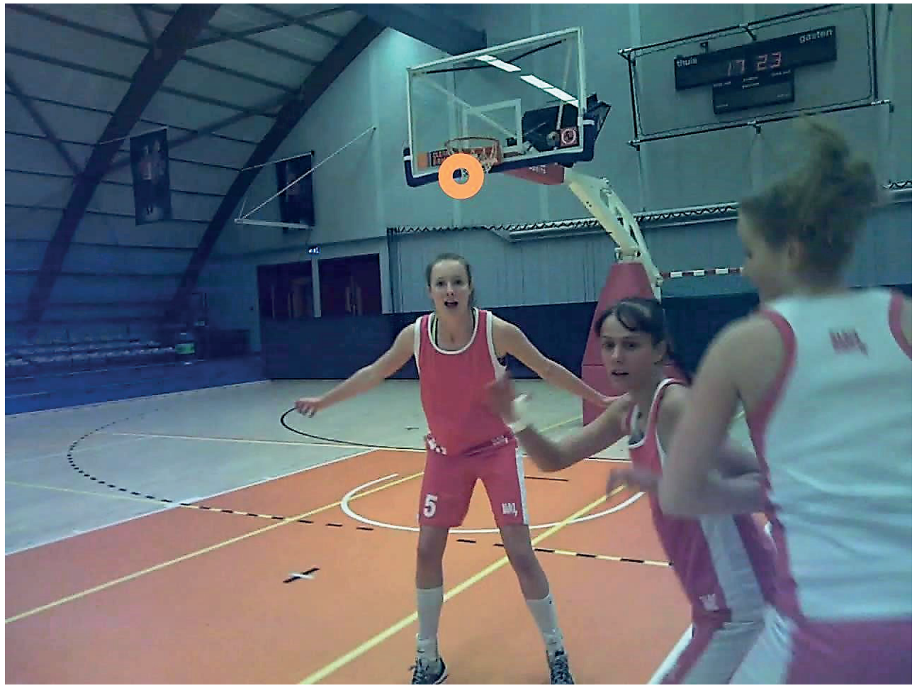

Figure 1.3. Snapshot of video image of eye tracking device.

Measuring performance

Up to now in most sport clubs, players are selected on the subjective recommendation of talent scouts. Although some scouts have proven to have an eye for talent identification, scouts have only limited time to watch every potential talented player and the judgement is often based on intuition and subjective criteria. To complement the judgements of scouts, there is a clear need for clubs to develop more effective and objective procedures for talent identification (Reilly et al., 2000; Williams, 2000). In science, tactical skills of players have typically been measured using video-based tests of perceptual-cognitive skill. In these tests participants are presented with video clips of specific sport situations and are required to indicate their preferred action or response either verbally or by way of a button press (Abernethy & Russell, 1987b; Gorman et al., 2012; Savelsbergh et al., 2002). An important advantage of video is that it allows sport situations to be reproduced in a consistent manner from trial to trial, providing an objective method of evaluating performance (Williams & Ericsson, 2005). A disadvantage, however, is that the two-dimensional presentation provides less information than available in the natural performance setting and thus may not adequately maintain the dynamic nature of the situation (Mann et al., 2007; Williams & Ericsson, 2005). Furthermore, participants are often required to respond verbally or by way of a button press, implying that they are required to make a perceptual judgement (generally considered to be perceptual responses) instead of an actual movement (an action response); thus perception and action are decoupled by excluding action from the participant response.

According to the two-visual system model of Milner and Goodale (1995, 2008) perception and action rely on two neuro-anatomically separate visual pathways within the brain: the ventral ‘vision-for-perception’ stream is proposed to be used for perceiving what action a situation affords, whereas the dorsal ‘vision-for-action’ stream is responsible for the visual control of that action. Laboratory study designs in which perception and action are decoupled may have failed to combine the complementary functions of the two cortical pathways, overemphasizing the role of the ventral stream and underrating the contribution of the dorsal stream that is most likely to be relied upon during action performance (Van der Kamp, Rivas, Van Doorn, & Savelsbergh, 2008). This distinction provides reason to believe that video-based tests of perceptual-cognitive skill are likely to result in the pick-up of different sources of visual information and the under-representation of the true ability of skilled performers, when compared to performing in an actual performance setting. This has been supported by several empirical studies (e.g., Dicks, Button, & Davids, 2010; Mann, Abernethy, & Farrow, 2010) and meta-analyses showing differences in both movement and visual behaviour when comparing laboratory studies and natural experimental settings (Mann et al., 2007; Travassos et al., 2013). For example, Dicks et al. (2010) examined gaze and movement behaviour of soccer goalkeepers during the penalty kick under two video-simulation (i.e., verbal and joystick movement responses) and three in-situ conditions (i.e., verbal, simplified body movement, and interceptive responses). They found that goalkeepers made more saves and fixated earlier on the ball and for longer periods of time in the in-situ condition where actual interception was required compared to the other conditions.

In summary, appropriate sampling of environmental conditions in experimental designs is a pressing issue in the perceptual expertise literature (Dicks et al., 2010). Although the traditional video-based perceptual-cognitive skill tests offer a significant advantage in terms of their methodological rigour and control, there has been increasing criticism on how well these tests accurately represent the on-field performance they are designed to sample (Mann & Savelsbergh, 2015; Pinder, Headrick, & Oudejans, 2015; Williams & Ericsson, 2005). Research on perceptual-motor behaviours needs to thoroughly consider the representativeness of the performance environment, the requisite responses of participants, and the variables used to measure performance (Travassos et al., 2013). Subsequent to the first two stages of the expert performance approach (Ericsson & Smith, 1991), in which the aim was to capture expert performance reliably and objectively and to identify underlying mechanisms, in the last stage the aim is to examine how expertise can be developed.

Improving performance using feedback

There is no question that practice is needed to improve performance in team sports. An interesting question, however, is how the enhancement of performance can be facilitated through appropriate training interventions, and more specifically how augmented feedback should be used as it is one of the most important variables for motor learning (e.g., Magill, 2004; Schmidt & Lee, 2005). Augmented feedback refers to information that is not inherent to the task, it comes from the coach, teacher, trainer or training device (Magill & Anderson, 2012). Insight into augmented feedback is beneficial for both sport scientist and practitioners. For the sport scientist, it provides insight into the learning process of skill acquisition, whereas for the practitioner it can help developing instruction and practice strategies that will facilitate the learning of skills (Magill & Anderson, 2012).

When augmented feedback is given to an athlete it can function in at least three ways. Augmented feedback (i) provides information that allows an athlete to determine what he or she should continue to do and what not when learning a new skill, (ii) provides information that allows an athlete to determine how to improve performance in specific contexts and situations when improving performance of well-learned skills, and (iii) can function as motivation to continue to practice a skill (Magill & Anderson, 2012).

An important issue regarding augmented feedback is how often and when feedback should be given. When feedback is scheduled too frequently the learner can become dependent on augmented feedback, as it may prevent the learner from processing intrinsic feedback that is relied on when augmented feedback is withdrawn (Chiviacowsky

& Wulf, 2007). According to the 'guidance hypothesis' feedback is particularly important after poor attempts as it guides the learner to the correct performance (Salmoni, Schmidt, & Walter, 1984), whereas Chiviacowsky and Wulf (2007) have shown that feedback after good rather than poor trials facilitates learning. When allowing learners to control their own feedback schedule, insight could be gained into their feedback preferences. Several empirical studies have shown that self-controlled feedback is beneficial for learning a variety of tasks, including aiming tasks (Chiviacowsky, Wulf, de Medeiros, Kaefer, & Tani, 2008; Janelle, Barba, Frehlich, Tennant, & Cauraugh, 1997), sequential timing tasks (Chen, Hendrick, & Lidor, 2002; Chiviacowsky & Wulf, 2002), trampoline jumping (Ste-Marie, Vertes, Law, & Rymal, 2013), and the basketball set shot (Aiken, Fairbrother, & Post, 2012). The studies involving a simple motor task (i.e., sequential timing task or beanbag tossing task) revealed a preference of self-controlled learner for feedback after good trials (Chiviacowsky & Wulf, 2002; Chiviacowsky et al., 2008; Chiviacowsky, Wulf, Wally, & Borges, 2009; Patterson & Carter, 2010), whereas in studies using more complex motor tasks (e.g., basketball set shot, juggling) this preference was not found (Aiken et al., 2012; Laughlin et al., 2015). Up to now, all studies conducted on self-controlled feedback have used individual tasks. It has yet to be determined what the feedback preferences are and whether self-controlled feedback is also beneficial for learning when examining complex skills that involve multiple persons, such as tactical skills in team sports.

Study aims and outline

The overall aim of this thesis is to determine how to measure tactical skills in team sports reliably and objectively, in order to gain more insight into tactical skills and how to improve tactical skills in team sports.

Chapter 2 describes a study in which pattern recall skills of soccer players were examined using two new methods of analysis. Since we hypothesized that the positions of players relative to each other may be more important for pattern recall accuracy than the exact positions of the separate players, and that the 2D perspective of the video images of the actual 3D situations may have caused a perspective bias, we introduced two new methods to analyse pattern recall accuracy. Instead of measuring absolute positions of separate players expressed as pixel coordinates, we measured geometric pattern features in terms of angles between players, and pattern recall accuracy converted into real-world coordinates. With these new analysis methods, we investigated the differences in pattern recall performance within a group of talented female soccer players and we explored the role of gaze behaviour in recalling patterns of play.

In Chapter 3 an objective and detailed notational analysis system was developed to assess player performance both on and off the ball in small-sided soccer games. The notation system was tested on female soccer players from the national talent program and validity and reliability were determined. Subsequently, the notation system was used in Chapter 4 to assess the in situ performance of skilled soccer players and to relate it to their performance on separate video-based tests of anticipation, decision making, and pattern recall in order to examine how well these tests accurately represent the on-field performance they are designed to sample. In this study, we also sought to determine the degree to which the three tests of perceptual-cognitive skill were related by exploring the correlations between the tests and the similarity of the gaze of participants when performing those tasks.

Chapter 5 describes one of the first studies examining decision-making skills and gaze behaviour in situ, with the aim to directly relate gaze behaviour to decision-making performance. Skilled basketball players participated in actual play situations on the court, while concurrently wearing a mobile eye tracking device. We compared the trials in which the players did and did not wear the eye tracking device to determine whether wearing it influenced the decision making or performance of the players. We examined where players looked during the dynamic development of each play to gain insight into the visual information that the players used to make their decisions and control their actions.

After these studies focusing on how to measure tactical skills in team sport, the final experimental chapter concerns the improvement of tactical skills. More particular, Chapter 6 describes a study in which the aim was to examine the effects of self-controlled video feedback on tactical skills in small-sided soccer games. Highly talented youth soccer players were assigned to a self-control or yoked group and received video feedback on their offensive performance in 3 vs. 2 small-sided games. The conversations between the players and coach while watching the video feedback were transcribed and analysed. We examined the preferences of the players for how often and when to receive video feedback, whether the video feedback was used to correct errors or to confirm correct performance elements, and whether self-controlled video feedback stimulates the learners' involvement in their own learning process.

Finally, Chapter 7 (Epilogue) summarizes and highlights the main findings of this thesis. Directions for future research are identified and practical implications are given for coaches and athletes on how to improve tactical skills in team sports.