PERCEPTUAL EXPERTISE IN SPORT: SOME MYTHS AND REALITIES

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Introduction

The area of perceptual skill in sport has attracted significant interest in recent years (e.g., see Starkes & Allard, 1993; Williams, Davids, & Williams, 1999). Sport scientists and practitioners alike have devoted much effort in attempting to determine the characteristics underlying perceptual skill and its acquisition. As a consequence of this endeavor, knowledge of the factors contributing to skilled performance has improved markedly and there has been progression from intuitive to evidence based practice (e.g., see Elliott, 1998). The aim of this paper is to highlight key findings that have emerged from this area of study over the past two decades, with particular reference to research involving soccer. Various myths and realities about perceptual expertise are presented, implications for practice considered, and avenues for future work briefly highlighted. Initially, some of the important myths surrounding the area are dispelled.

Some Common Myths about Perceptual Expertise in Sport

1. Skilled performers possess superior visual systems compared to less skilled counterparts

The research findings are somewhat equivocal, but the general consensus is that skilled performers do not possess superior visual systems compared to less skilled counterparts. Ward, Williams, and Loran (2000) tested 137 elite and sub-elite soccer players between 8 and 18 years of age using standard measures of static and dynamic visual acuity, stereoacuity, and peripheral awareness. A main effect was observed for Age, with general improvements in visual function apparent up to 13 years of age, however, there was no main effect for Skill. The elite and sub-elite players were not consistently differentiated based on measures of visual function. The visual system may set the limits to performance, but these do not appear to be related to skill level (cf. Helsen & Starkes, 1999; Williams et al., 1999). Although the relative importance of visual skills may vary with the constraints of the task, having above average levels of visual function does not facilitate the acquisition of perceptual skill in team ball games such as soccer.

2. There is no evidence to suggest that perceptual skills transfer across sports

Several researchers have suggested that perceptual expertise is specific to a particular task or domain (e.g., Abernethy, 1994; Allard & Starkes, 1992), with relatively little transfer from one sport to another. However, recent research suggests that this observation may not be as parsimonious as previously reported. An initial pilot study by Ward, Williams, Smeetson, and Wood (2001) shows that there is some transfer of pattern recognition skills (as determined using the recognition paradigm) between soccer and field hockey. In keeping with various theoretical models, the amount of positive transfer from one sport to another is dependent on the degree of similarity with regard to the typical patterns of play, strategies, and tactics adopted within each sport. Also, there is evidence to suggest that having the opportunity to participate in a wide variety of related sports at an early age may be beneficial in the development of perceptual skill (Abernethy, Côté, & Baker, 2000). Further research is required to identify the factors underpinning the successful transfer of perceptual skill across sports and to determine key stages for encouraging diversification and specialization.

3. Perceptual skill can not be improved through practice and instruction

A widely held belief, at least among practitioners, is that perceptual skill is genetically determined and not particularly amenable to practice and instruction. Empirical evidence indicates that cognitive interventions that develop the knowledge bases underlying skilled perception have practical utility in facilitating the acquisition of expert performance (Williams & Grant, 1999). Video simulation may be particularly effective as a method of developing perceptual skill, particularly when coupled with appropriate instructional techniques. There is some tentative evidence to suggest that skilled performers are able to benefit from perceptual training more than their less skilled counterparts (e.g., see Williams & Davids, 1995), although the extent to which such factors may impinge upon talent identification has yet to be determined (Williams, 2000). Avenues for future work in this area are highlighted elsewhere (see Williams & Grant, 1999; Williams & Ward, 2001).

While the issues raised above highlight common misconceptions, a number of facts or 'realities' about the nature of perceptual expertise in sport have been established in recent years.

Some Key Facts about Perceptual Expertise in Sport

4. Experts are able to recognize and recall structured patterns of play

Experts are better than novices at recognizing and recalling patterns of play because their knowledge and domain-specific memory skills allow them to 'chunk' or group perceptual information (i.e., individual players) into larger and more meaningful units (i.e., patterns of play). Williams, Davids, Burwitz, and Williams (1993) presented expert and novice soccer defenders with 'structured' and 'unstructured' film sequences taken directly from match play. Following each 10-second action sequence, participants were required to recall players' positions by entering schematic representations on a computer-generated image of a soccer field. As highlighted in Figure 1, experts had smaller errors when recalling players' positions compared to novices on the structured trials only. Experts' superiority in recall was not observed on the unstructured trials since these were intended as a control condition to ensure that there were no differences between groups in visual short term memory. In a related study, Williams and Davids (1995) used the recognition paradigm to show that expert soccer defenders are faster and more accurate than their novice counterparts in recognizing previously viewed action sequences. The experts superior ability to encode and retrieve sport-specific information is due to more complex and discriminating memory structures and is the strongest predictor of anticipation skill in team ball games (e.g., see Williams & Davids, 1995). Experts are aware of the typical defensive and offensive patterns used by their opponents, and consequently, are able to recognize an evolving pattern of play much earlier in its development, thereby facilitating anticipation (for a detailed review of research involving other sports, see Williams et al., 1999). Further research work is required to determine the minimal essential information underlying pattern recognition skills in various sports. The use of visual search, point light, and event occlusion paradigms may offer practical utility in this regard.

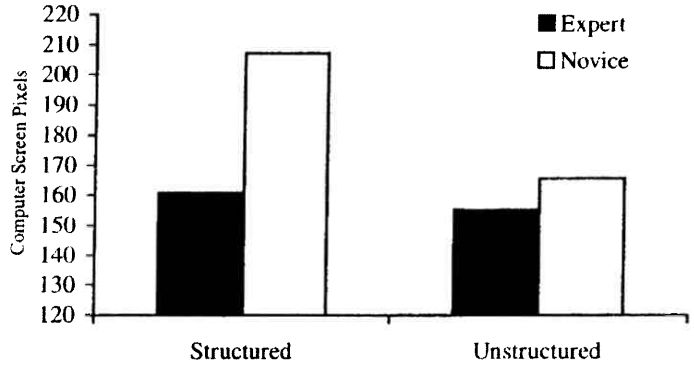

Figure 1. Mean recall error per player in computer screen pixels for expert and novice soccer players across stimulus conditions.

5. Experts are able to anticipate opponents' actions using advance visual cues

The ability to anticipate opponents' actions based upon partial or advance sources of information is essential in sport because of the severe time constraints placed on performers. A considerable research base confirms the expert's superior ability to use such information in sport (for a review, see Williams et al., 1999). In one study, Williams and Burwitz (1993) employed a film based temporal occlusion approach to show that expert soccer goalkeepers are more successful than novices in anticipating the direction of a penalty kick. Experts were able to rely on earlier sources of information, particularly from the penalty-taker's run up and postural orientation prior to foot/ball contact. When attempting to anticipate the appropriate side, information was derived from the penalty taker's angle of run-up, arc of the leg on approach to the ball, and angle of the kicking foot and hip prior to ball contact. The hip position at impact was particularly informative. For a right-footed kicker, the 'opening' of the hips suggests that the ball is about to be played to the goalkeeper's left, whereas a penalty played to the goalkeeper's right is characterized by a more 'closed' or central orientation of the penalty taker's hips relative to the goalkeeper. The assumption is that similar sources of information may also be employed by outfield players to anticipate an opponent's intended pass destination. Little, if any, work has been carried out on the effects of disguise and given its importance in sport this shortcoming in the literature needs to be addressed.

6. Experts employ efficient and effective visual search strategies

Experts are able to use their superior knowledge to control the eye movement patterns necessary for seeking and picking up important sources of information. When compared to novices, experts focus their gaze on more informative areas of the display, enabling them to effectively anticipate action requirements (for a detailed review, see Williams et al., 1999). Although data has been collected in-situ in sports like tennis (Singer et al., 1998) and basketball (Vickers, 1996), the majority of studies have been undertaken using film based simulations as highlighted in Figure 2.

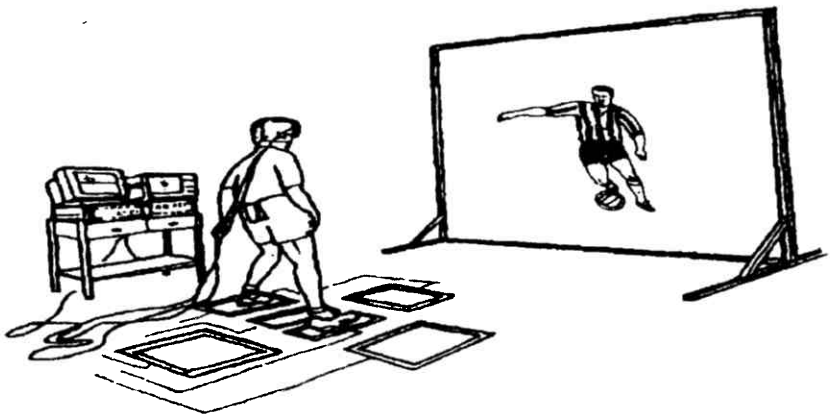

Figure 2. The experimental set-up used to examine visual search behaviors during 1 vs. 1 simulations in soccer.

Current understanding suggests that the search behaviors employed during sporting actions depend on the constraints of the task as well as participant skill level. For example, search strategies vary when viewing the whole field (i.e., 11 vs. 11 simulations) compared to specific situations within the game (e.g., 1 vs. 1 duel). Similarly, different gaze behaviors are employed in defensive and offensive contexts. In 11 vs. 11 simulations novice soccer defenders fixate more frequently on the ball and the player passing the ball, whereas expert defenders employ a more extensive search strategy involving more fixations of shorter duration to disparate areas of the field (Williams, Davids, Burwitz, & Williams, 1994). Novice defenders are guilty of 'ball watching', whereas skilled players fixate on the positions and movements of players 'off the ball'. In 3 vs. 3 defensive simulations expert defenders employ fewer fixations of longer duration than their less skilled counterparts (Williams & Davids, 1998). In these more time constrained situations, expert defenders extract pertinent information from the passing player's posture through central vision (e.g., orientation of the hips, shoulders and lower leg region), while using peripheral vision to obtain confirmatory information regarding the movements of attacking players 'off the ball'. In 1 vs. 1 'duels' skilled defenders employ more fixations of shorter duration and fixate for longer on the hip region compared with their novice counterparts (Williams & Davids, 1998). Expert players alternate their fixations between ball and hip regions more frequently than novices, indicating that these areas, as in the penalty kick scenario, are important in anticipating opponents' movements.

Visual search behaviors also differ between defensive and offensive situations. Skilled players demonstrate higher search rates (i.e., more fixations of shorter duration) during defensive 11 vs. 11 simulations when compared with similar offensive situations (e.g., see Helsen & Pauwels, 1993). In defensive situations there is no immediate temporal pressure from the opposition and time is available to undertake a comprehensive analysis of the display. A search strategy that involves periodically scanning back and forth from the ball to informative areas of the display, such as the runs of attacking players, is more advantageous than fixating on the passing player or ball alone. During similar offensive situations, attackers have less time to scan the display and may be constrained to respond as soon as a suitable attacking opportunity arises.

7. Experts are able to pick up the minimal essential information underlying skilled perception

Skilled performers appear more attuned to relative motion cues and are able to successfully perceive information presented as point light displays (PLD). Ward, Williams, and Bennett (2000), in a study involving tennis forehand and backhand strokes, observed that, despite a small decrement in performance, the differences in anticipatory performance between expert and novice players were maintained when viewing point light compared to normal film displays. It appears experts are able to extract kinematic or biological motion information from the display better than novices. Also, unlike their novice counterparts, experts exhibit more consistent visual search strategies when viewing PLD compared with a normal display. It may be that the relative motion information presented during transition from one illusory position to another (e.g., rotational information from the hips prior to striking the ball in a penalty kick situation) provides the minimal essential information source underlying skilled perception. Point light displays offer a potentially fruitful approach in attempting to identify the invariant sources of

information underlying perceptual skill during the performance and learning of movement skills (e.g., see Horn, Williams, & Scott, 2001).

8. Experts have superior knowledge of situational probabilities

As well as their enhanced ability to extract contextual information from the display, experts use knowledge stored in long-term memory to establish accurate expectations of likely events as the pattern of action unfolds. Experts dismiss many events as being 'highly improbable' and can attach a hierarchy of probabilities to the remaining events, thus facilitating anticipation (see Williams et al., 1999). Anticipatory movements may be guided by these initial expectations while confirmatory movements are based on contextual information present within the display (e.g., effective pick-up of postural cues or recognition of an evolving pattern of play).

In a recent study, elite and sub-elite soccer players were asked to assign probability values to the 'best passing options' available to a player in possession of the ball (Ward & Williams, 2001). Various film sequences were paused immediately prior to the ball being passed and participants were required to highlight likely passing options. As highlighted Figure 3, elite participants were better than the sub-elite group at identifying players who were in the best position to receive the ball and were more accurate in assigning an appropriate probability to players in threatening and non-threatening positions, as determined by a panel of expert coaches. It appears that experts 'hedge their bets' more than novices judiciously putting both their expectations and the more effective processing of contextual information to effective use. The sub-elite players, in contrast, were less efficient in their selection of critical and non-critical players and were not as adept at assigning a hierarchy of probabilities to likely events.

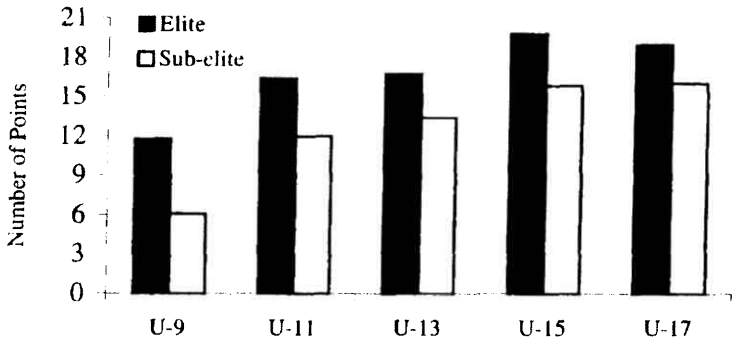

Figure 3. Mean number of points awarded to elite and sub-elite soccer players between 8 and 18 years of age as a result of accurately matching assigned probability values.

9. The perceptual processes of experts are less affected by changes in emotional state

Experts' visual search behaviors are more robust than those of novices to changes in emotional state as a function of anxiety. Williams and Elliott (1999) required expert and novice performers to move in response to filmed karate attacking sequences when experiencing low and high levels of cognitive anxiety. Anxiety had a significant effect on search strategy, particularly for the novice group, highlighted by an increase in the number of fixations and total number of fixation locations and a reduction in mean fixation duration per trial. Generally, there was a shift in gaze from central to more peripheral body locations, presumably due to peripheral narrowing, hypervigilance effects or increased susceptibility to task-irrelevant information (Janelle, Singer, & Williams, 1999). Further research is required to determine how anxiety interacts with other emotions and with physiological arousal or fatigue to constrain perceptual processes in sport (e.g., see Vickers, Williams, Rodrigues, Hillis, & Coyne, 1999).

10. Perceptual skills develop at an early age

While physical factors are often used to try and discriminate between skill groups at an early age, perceptual skill has been shown to be more predictive of talent as children mature (Reilly, Williams, Nevill, & Franks, 2000) and consequently, is predicted to improve markedly during early adulthood (Abernethy, 1988). However, Ward and Willams (2001) demonstrated that elite and sub-elite soccer players could be differentiated on the basis of their perceptual skill as early as 9 to 11 years of age. The elite players were better than age-matched, sub-elite participants in using advance visual cues and in allocating

hierarchical probabilities to possible events at 9 years of age (see Figure 3). There was a general tendency for initial differences between skill groups to increase progressively up to 17 years of age. Similarly, while both elite and sub-elite soccer players improved their ability to recall from memory typical patterns of attacking and defensive play between 11 and 13 years of age, elite players continued to improve these skills, beyond that demonstrated by sub-elite players, between 15 and 17 years of age. An important issue is whether key 'time windows' exist for the development and acquisition of perceptual skill in sport.

The intention in this paper was to present some major observations on the nature of perceptual expertise in sport. It appears that experts have several advantages over their novice counterparts. These advantages are presumed to reflect the experts enhanced computational sophistication and improved strategic processing of sport-specific information (Abernethy, 1994). As a result of experience, accumulated through many hours of deliberate, purposeful practice (Helsen, Hodges, Van Winckel, & Starkes, 2000), experts have developed an extensive knowledge base that enables them to establish accurate expectations of likely events and to confirm these predictions through the effective processing of contextual information. These skills appear to develop at an early age and are amenable to improvement through positive transfer from related activities and via specific training and instruction.

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