Human Movement Science 57 (2018) 205–216

Contents lists available at ScienceDirect

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

Full Length Article

In situ examination of decision-making skills and gaze behaviour of basketball players

Mariëtte J.J. van Maarseveen[a,*], Geert J.P. Savelsbergh[a,b,c], Raôul R.D. Oudejans[a,b,c]

[a] Department of Human Movement Sciences, Vrije Universiteit Amsterdam, Amsterdam Movement Science, The Netherlands
[b] Institute of Brain and Behavior Amsterdam, The Netherlands
[c] Faculty of Sports and Nutrition, Amsterdam University of Applied Sciences, The Netherlands

ARTICLE INFO

Keywords:
Embodied choice
Visual search strategy
Representative design

ABSTRACT

In this study we examined in situ decision-making skills and gaze behaviour of skilled female basketball players. Players participated as ball carriers in a specific 3 vs 3 pick-and-roll basketball play. Playing both on the right and left side of the court and facing three types of defensive play, they chose and performed one of four options: shoot, drive to the basket, pass to the screener or pass to the corner player. We concurrently measured gaze behaviour to examine the direct relationship between gaze and decision making. As one of the first studies examining decision making and gaze behaviour in situ, this study found support for the embodied choice framework as the results showed that handling the ball with the dominant or non-dominant hand influenced the decisions that were made. Gaze measures suggested that peripheral vision may serve a significant role in decision making in situ, whereas players mainly relied on central vision to execute an action. Furthermore, this study underlined the need for developing and using newer and more informative methods to analyse gaze.

1. Introduction

Decision making is an important aspect of sport performance. In invasion games like basketball, soccer and hockey, a player has to read the game and decide upon and perform an appropriate action in a complex dynamic and time-constrained environment. It is well established that experts possess superior perceptual-cognitive skills including recognizing and recalling meaningful patterns of play (Gorman, Abernethy, & Farrow, 2012; Van Maarseveen, Oudejans, & Savelsbergh, 2015), predicting the outcome of another person's action on the basis of pick-up of early visual information (anticipation; Abernethy & Russell, 1987; Savelsbergh, Williams, Van der Kamp, & Ward, 2002; Williams & Ward, 2007), and making accurate decisions regarding the developing course of action (i.e., the ability to select the best possible option from a variety of alternatives; Gorman, Abernethy, & Farrow, 2013; Helsen & Pauwels, 1993; Roca, Ford, McRobert, & Williams, 2011; Vaeyens, Lenoir, Williams, Mazyn, & Philippaerts, 2007a; Williams & Davids, 1998; Williams, Davids, Burwitz, & Williams, 1994). An interesting question is how athletes make decisions in complex and time-constrained situations. This involves both the visual information relied upon and the cognitive processes needed to interpret the visual information and choose an option.

One possible way to gain insight into how athletes make decisions in complex and time-constrained situations is through the examination of gaze behaviour. Eye registration techniques have been increasingly used in sport science to gain insight into the visual

* Corresponding author at: Department of Human Movement Sciences, Vrije Universiteit Amsterdam, Amsterdam Movement Science, Van der Boechorststraat 9, 1081 BT Amsterdam, The Netherlands.
E-mail addresses: m.van.maarseveen@vu.nl (M.J.J. van Maarseveen), g.j.p.savelsbergh@vu.nl (G.J.P. Savelsbergh), r.oudejans@vu.nl (R.R.D. Oudejans).

https://doi.org/10.1016/j.humov.2017.12.006
Received 23 February 2017; Received in revised form 19 May 2017; Accepted 7 December 2017
0167-9457/

search strategies of expert athletes and consequently to use these insights to improve the performance of lesser-skilled athletes, for example to enhance the visual control of the basketball shot (Oudejans, 2012; Oudejans, Koedijker, Bleijendaal, & Bakker, 2005) and the interceptive performance of soccer goalkeepers (Savelsbergh, Van Gastel, & Van Kampen, 2010). However, there is much unknown about the visual information relied upon for skilled decision making in complex dynamic situations. This may be due to some substantial limitations to using eye registration techniques to gain insight into gaze behaviour (Mann, Farrow, Shuttleworth, & Hopwood, 2009; Ryu, Abernethy, Mann, Poolton, & Gorman, 2013; Williams & Davids, 1998; Williams, Janelle, & Davids, 2004). First, when fixating at a certain location, this does not mean that the observer is able to pick up information from that fixation location; “looking” is not necessarily “seeing” (Williams et al., 2004). Second, eye tracking devices measure where an observer is foveally fixating, but this does not reveal where the observer’s attention is at that time. Many sport situations require integration of information from the fovea, parafovea, and visual periphery (Ryu et al., 2013; Williams & Davids, 1998; Williams et al., 2004). For example, Ryu et al. (2013) examined the role of central and peripheral vision in expert decision making using a gaze-contingent display selectively showing video footage to the central or peripheral area of the visual field. When central vision was removed, and thus peripheral vision could only be used, the skilled players did not change the amount of time they spent directing their central vision towards the ball-carrier in comparison with full vision, even though this meant that the ball-carrier could not be seen. This suggests that the participants used the location of the ball-carrier as an anchor point and monitored the movement of the other players using peripheral vision. Therefore, in normal conditions with full vision, the fixation location could reflect the observer’s attention via central vision or could be used as an anchor point to extract information from the visual periphery (visual pivot; Ryu et al., 2013; Williams & Davids, 1998). Third, visual search strategies appear to be very context specific. Watching the same situation for different purposes or tasks, results in different visual search strategies (Gorman, Abernethy, & Farrow, 2015; North, Williams, Hodges, Ward, & Ericsson, 2009; Van Maarseveen, Oudejans, Mann, & Savelsbergh, 2016). For example, Van Maarseveen et al. (2016) found differences in the gaze of soccer players when watching the same video clips for the purposes of anticipation, decision making and pattern recall. But also with identical purposes the visual search strategies differ when varying number of players are displayed in the video clip (Vaeyens et al., 2007a; Williams & Davids, 1998). Finally, it is difficult to capture the visual search strategies employed in dynamic sport situations with the traditionally used dependent variables like search rate and fixation duration (Mann et al., 2009), and thus there is a need to develop new methods to analyse gaze behaviour. Examples include time series graphs (Mann et al., 2009), eye fixation scan paths (Underwood, Phelps, Wright, Van Loon, & Galpin, 2005), and the combination of eye tracking and verbal protocols (Williams et al., 2004).

Moreover, decision-making skills and gaze behaviour have typically been measured using simplified video-based tests in which participants do not actually move, but respond verbally or by way of a button-press while concurrently wearing an eye tracking device. Although these simplified tests offer a significant advantage in terms of their methodological rigour and control, there is increasing evidence that these tests do not accurately represent the on-field performance they are designed to sample (Dicks, Button, & Davids, 2010; Mann, Abernethy, & Farrow, 2010; Mann, Williams, Ward, & Janelle, 2007; Pinder, Headrick, & Oudejans, 2015; Travassos et al., 2013; Van Maarseveen et al., 2016). First, significant differences have been found in both movement and visual behaviour when comparing performance on traditional video-based tests with contexts that are more representative of the actual performance environment (Dicks et al., 2010; Mann et al., 2010; Pinder et al., 2015). For example, Dicks et al. (2010) showed that soccer goalkeepers made more penalty saves and fixated earlier and longer on the ball when actual interception was required compared to when responding to a video simulation. Second, meta-analysis has shown that expertise effects are most apparent when participants have to perform real actions under in situ task constraints compared to simplified responses in less representative environments (Mann et al., 2007; Travassos et al., 2013). Third, Van Maarseveen et al. (2016) have shown that on-field performance of soccer players could not be predicted on the basis of performance on video-based tests of perceptual-cognitive skill.

The less representative research designs may be unsuitable to gain insight into expert performance in complex domains such as team sports due to decoupling of perception and action (Mann et al., 2010; Savelsbergh, Onrust, Rouwenhorst, & Van der Kamp, 2006). Decision making is not a serial process, in which the decision is made first and then the action is executed, but the perceptual and motor components of decision making seem to be intertwined. According to the framework of Embodied Choice “action performance is considered as a proper part of the decision making process” (Lepora & Pezzulo, 2015, p. 2) and not only the end product of the cognitive decision; instead there are bidirectional influences between actions and decisions. This implies that in sports, where decisions may be expressed as actions, the action dynamics and constraints (e.g., speed, body orientation, or handling the ball with the dominant or non-dominant hand or foot) influence the decision making process. Therefore, action and perception cannot be examined separately in such a complex domain as sports. This highlights the necessity of measuring perceptual-motor skills in the actual performance environment, thus using in situ research designs in which a natural perception-action coupling is preserved. Surprisingly though, hardly any studies have been conducted on the direct relationship between decision-making skills and gaze behaviour using an in situ design (for an exception see Martell & Vickers, 2004). The current study is one of the first studies examining decision making and gaze behaviour during actual play situations on the court (thus in situ), with the aim to directly relate gaze behaviour to decision-making performance. To this end, skilled basketball players performed 3 vs. 3 pick-and-roll plays on the court. The pick-and-roll is an offensive play in which a player sets a screen (“pick”) for his ball handling teammate and then moves (“rolls”) behind the defender towards the basket to get open for a pass. In this way, the team mate of the ball carrier blocks out the defender, creating space and time for the ball carrier. In this research design, the ball carrier had four options after the pick-and-roll: shooting at the basket, driving towards the basket followed by a lay-up, passing to the teammate who set the screen or passing to an additional teammate in the corner of the court. Playing both on the left and right side of the court and facing three different defensive plays, the ball carrier had to decide upon and perform one of the four options. We examined the differences in decisions among defensive plays and between sides of the court. We expected a different pattern of decisions for each of the defensive plays, and for