Human Movement Science 39 (2015) 12–26

Contents lists available at ScienceDirect

Human Movement Science

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

Which technology to investigate visual perception in sport: Video vs. virtual reality

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ARTICLE INFO

Article history:
Available online 20 November 2014

PsycINFO classification:
3720

Keywords:
Virtual reality
Video
Visual perception
Kinematic analysis
Goalkeeping

ABSTRACT

Visual information uptake is a fundamental element of sports involving interceptive tasks. Several methodologies, like video and methods based on virtual environments, are currently employed to analyze visual perception during sport situations. Both techniques have advantages and drawbacks. The goal of this study is to determine which of these technologies may be preferentially used to analyze visual information uptake during a sport situation. To this aim, we compared a handball goalkeeper's performance using two standardized methodologies: video clip and virtual environment. We examined this performance for two response tasks: an uncoupled task (goalkeepers show where the ball ends) and a coupled task (goalkeepers try to intercept the virtual ball). Variables investigated in this study were percentage of correct zones, percentage of correct responses, radial error and response time. The results showed that handball goalkeepers were more effective, more accurate and started to intercept earlier when facing a virtual handball thrower than when facing the video clip. These findings suggested that the analysis of visual information uptake for handball goalkeepers was better performed by using a 'virtual reality'-based methodology. Technical and methodological aspects of these findings are discussed further.

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http://dx.doi.org/10.1016/j.humov.2014.10.006
0167-9457/

1. Introduction

In sports involving interceptive tasks, like baseball, soccer, tennis or handball, one of the fundamental elements of performance is the ability to decode a human's or an object's trajectory as effectively as possible, in order to be at the right place, at the right time (Williams, Davids, & Williams, 1999; Williams, Vickers, & Rodrigues, 2002). This anticipation is based on picking up and selecting salient visual information of the situation (Abernethy, 1988). For example, in tennis, the visual information available before the impact between the racket and the ball is critical in order to identify the falling point of the ball (Goulet, Bard, & Pleury, 1992). Similarly in karate, fighters need to uptake visual information from the head and chest of their opponent in order to anticipate their actions (Williams & Elliott, 1999). Finally in handball, goalkeepers seem to focus on the shooter's arm holding the ball to prepare their movement (Debanne, 2003).

To investigate realistic situations, several methods have been used in the literature to analyze visual perception directly by interviewing players (Debanne, 2003), by using liquid crystal glasses that can block vision at a specific time (Müller & Abernethy, 2006; Starkes, Edwards, Dissanayake, & Dunn, 1995), or by recording gaze behavior throughout the action (Dicks, Button, & Davids, 2010; Panchuk & Vickers, 2006; Rodrigues, Vickers, & Williams, 2002; Williams & Davids, 1998). Concerning experimental design, it has been demonstrated that requiring subjects to perform sport actions in *in situ* conditions permits to assess decision-making expertise in sport (Mann, Abernethy, & Farrow, 2010; Travassos et al., 2013). However, using a simulated experimental design may help to examine the influence of one piece of visual information taken by the athlete when several elements evolve at the same time. Using a standardized and reproducible environment may thus be an asset when analyzing visual perception in sports (Loomis, Blascovich, & Beall, 1999). Two methods can be used for that purpose: video-based or virtual reality (VR) method. The goal of this work is to compare the use of these two methods for the analysis of visual perception. It is applied to the duel between a thrower and a goalkeeper in handball.

Video-based methods were used first to analyze visual perception in standardized environments and are still widely employed due to its ease of implementation. It consists in observing a participant's response in front of a sport action recorded during a game-like situation. From a methodological point of view, several approaches have been used to analyze this participant's response. Some were interested in the temporal aspect of the answer by computing the time delay used for responding to the video clip (Williams & Davids, 1998; Williams, Davids, Burwitz, & Williams, 1994). Others tried to identify significant visual information used by the subject by employing a temporal occlusion paradigm (Abernethy, 1987; Farrow & Abernethy, 2003). In this approach, the amount of visual information presented to participants is temporally controlled by cutting off the video clip at different key moments of the action. Such critical instants can correspond to the end of a throwing motion in cricket (Müller, Abernethy, & Farrow, 2006), the beginning of a ball trajectory in soccer (Savelsbergh, Van der Kamp, Williams, & Ward, 2005), the racket/ball contact in tennis (Fukuhara, Ida, Kusubori, & Ishii, 2009), or the ball release from the hand in handball (Cañal-Bruland & Schmidt, 2009; Cañal-Bruland, van der Kamp, & van Kesteren, 2010). However, video-based presentation has several limitations (Abernethy, Thomas, & Thomas, 1993; Bideau et al., 2010; Williams et al., 1994). The first drawback concerns the two-dimensional display of the video projection. With this method, the subject cannot extract stereoscopic information, as in real life. Moreover, many studies have demonstrated the influence of stereoscopic information on motor responses (Mazyn, Lenoir, Montagne, & Savelsbergh, 2004; Yeh & Silverstein, 1992). The second limitation is linked to the viewpoint of the subject during the experiment. As their decisions are based off the view of the camera, it cannot be updated in real-time if the subject moves during the experiment. In a real sport situation, different visual information may be extracted from the environment depending on the subject's viewpoint. Although strong experimental control is often provided, video-based methods have several drawbacks that lead researchers to explore other technologies.

VR technology can address these limitations. VR consists of creating numerical simulations in immersive environments and is now being used as a tool to analyze and understand performance in sport (Bideau et al., 2010; Craig, 2014; Katz et al., 2006). VR has a number of advantages over video