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Visual perception in basketball shooting

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The general aim of the research presented in the present thesis was to elucidate the visual basis of basketball shooting. Chapter 1 provides an overview of the pertinent literature. Previous studies on the topic focused on temporal aspects of vision and identified the rapidity of orienting and stabilizing head and eyes on the target (Ripoll, Bard, & Paillard, 1986) and long target fixations (Ripoll, Bard, & Paillard, 1986; Vickers, 1996) as necessary ingredients for successful performance and distinguishing marks of expertise. In apparent contrast to the long target fixations, a more recent study highlighted the benefits of looking at the target late (Oudejans, van de Langenberg, & Hutter, 2002). To help resolve this issue we examined the preferred timing of optical information pick-up in Chapter 2, the effects of online and offline visual control in Chapter 3, and the gaze behaviour during the preparation and execution of the shooting movements in Chapter 4. In addition to the temporal aspects of vision, we investigated the information sources that are used to guide basketball shooting in three experiments, which are reported in Chapter 5. The contents of these chapters may be summarized in greater detail as follows.

In Chapter 2 we investigated the preferred timing of optical information pick-up and how this depended on the shooting style used. Our hypothesis was that expert basketball players prefer to look at the target as late as permitted by their shooting style. The employed shooting style determines whether or not a player can see the basket following the moment when ball and hands pass the line of sight (mLoS). Players with a low shooting style can only see the basket before mLoS, whereas players with a high shooting style can see the basket after mLoS until ball release. To investigate when players with either type of shooting style prefer to view the basket, we used an intermittent viewing technique and a 3D movement registration system. We used liquid crystal glasses that intermittently turned transparent and opaque (for 350 and 250 ms, respectively). The 3D movement registration system Optotrak was used to determine mLoS.

Twelve expert basketball players, five with a low style and seven with a high style, participated in the experiment. Their percentage of hits under intermittent viewing was not significantly different from that under full vision, and was independent of shooting style. In a subsequent analysis, we mapped mLoS onto the events defined on the glasses, and used circular statistics to determine whether shooting-style dependent timing patterns were present. The results showed that in the low-style group mLoS occurred when the glasses became opaque, implying that the players could see the basket just before mLoS. In the high-style group, mLoS occurred near the moment when the glasses became transparent, implying that the players could see the basket just after mLoS until ball release. In other words, both groups viewed the basket as late as their shooting kinematics allowed. In addition to confirming our hypothesis, these results support the view that basketball shooting is controlled online by vision.

This view was examined further in Chapter 3, which reports an experiment that we conducted to determine whether basketball shooting relies primarily on online or offline visual control. Our hypothesis was that basketball players use online visual information to execute the shooting movements, in order to insure that performance is accurate. To test this hypothesis, we employed a visual delay paradigm. We used liquid crystal glasses that either remained transparent throughout movement execution, or became opaque zero, one, or two seconds before movement initiation. A movement registration system (Optotrak) was used to register the movements of the shooting arm (ring and little fingers, metacarpal area, wrist, elbow, shoulder) in 3D. Ball trajectories were recorded to estimate the landing position of the ball on the plane of the rim. Seventeen expert basketball players, eight with a low style and nine with a high style, participated in the experiment. Both the percentage of hits and the landing positions revealed marked decrements in performance with increasing delays. Furthermore, the analysis of covariance coefficients on the kinematic data revealed that the severity of visual conditions was associated with decreased coupling strength and increased variability between the arm joints. Even though most shots still landed in the vicinity of the basket in the absence of vision,

accuracy was significantly better under normal viewing. Although this study does not rule out the use of offline visual information, it underscores the online use of visual information in basketball shooting.

In Chapter 4 we investigated whether the gaze behaviour of expert basketball players was dependent on their shooting style and the type of basketball shot performed. Based on previous findings, we expected that low-style players would look long at the basket in the free throw but less long in the jump shot, and that high-style players would look at the basket after mLoS until ball release both in both the free throw and the jump shot. We invited six expert basketball players, three with a low style and three with a high style, to take ten jump shots and ten free throws while wearing an eye tracking system to register their looking behaviour. Looking behaviour was coded for each frame, such that looking at the rim was 1, the basket's net or small square on the backboard was 0.8, the remaining backboard was 0.6, other locations were 0.4 and no gaze behaviour was 0. Next, we analyzed the gaze behaviour directed at the basket or backboard before and after mLoS. The results were in accordance with our expectations. The low-style shooters looked at the target only before mLoS and for about 1 s in the free throw but half that duration in the jump shot, without any repercussions for shooting accuracy. The high-style shooters, in contrast, looked consistently at the target after mLoS both in the free throw and in the jump shot for about 400 ms.

In Chapter 5 we investigated the optical basis of basketball shooting in a series of three experiments. From a theoretical analysis it appeared that the absolute distance between player and basket (m) and the angle of elevation subtended by the line of gaze to the basket (α) could be used conjointly to determine the exact location of the basket. Alternatively, the location of the basket could be determined by using either m or α in combination with the height of the basket, which was always set at the same official height. In the first experiment it appeared that expert basketball shooters preserved good shooting accuracy when m and α were the only information sources available during movement execution. In the second experiment, accuracy was

maintained upon removal of information sources related to m , indicating that those information sources were less relevant for successful shooting. Finally, we tested the use of α by manipulating the height of the basket unbeknownst to participants. Consistent with the use of angle of elevation, participants misperceived heightened baskets as being closer and lowered baskets as being further away. We therefore concluded that angle of elevation information, calibrated to the official basket's height, was used for successful shooting.

In sum, the experiments presented in the present thesis provided clear insights into the visual basis of basketball shooting. They highlight the importance of the online use of visual information during movement execution and of using the latest and most updated visual information available. A likely variable that may be picked up and used to guide the shooting movements is the angle of elevation, which is informative about the distance from the player to the target provided that both perception and shooting action are calibrated to the official height of the basket. These insights have broad theoretical implications, as well as several possible applications, that are discussed in the sixth and final chapter of this thesis.