Shot deception in basketball: Gaze and anticipation strategy in defence

Johannes Meyer[1], Nicholas J. Smeeton[2], Frowin Fasold[1], Karsten Schul[1], Timo Schön[1], and Stefanie Klatt[1,2]

[1]Institute of Exercise Training and Sport Informatics, German Sport University Cologne, Am Sportpark Müngersdorf 6, 50933 Cologne, Germany

[2]Sport and Exercise Science and Medicine Research Group, University of Brighton, Mithras House, Lewes Road, Brighton, BN2 4AT, United Kingdom

Author Note

Declarations of interest: none

Correspondence concerning this article should be addressed to Johannes Meyer, Institute of Exercise Training and Sports Informatics, Department of Cognitive and Team/Racket Sport Research, German Sport University Cologne, Am Sportpark Müngersdorf 6, 50933 Cologne, Germany, E-mail: j.meyer@dshs-koeln.de, ORCiD: orcid.org/0000-0003-1443-8997

Highlights

- Research design with game-related movement responses and time context
- Results indicate that later occlusion points lead to more effective deceptions
- Experts were affected by the deception effect at later end points of the shot fake
- Fixations on the hip and legs seem to be the best strategy for anticipating shooting movements

Abstract

Anticipation of teammates and opponents is a critical factor in many sports played in interactive environments. Deceptive actions are used in sports such as basketball to counteract anticipation of an opponent. In this study, we investigated the effects of shot deception on the players' anticipation behaviour in basketball. Thirty one basketball players (15 expert, 16 novice) watched life-sized videos of basketball players performing real shots or shot fakes aimed at the basket. Four different shot outcomes were presented in the video stimuli: a head fake, a ball fake, a high shot fake, and a genuine shot. The videos were temporally occluded at three different time points (-160ms, -80ms, 0ms to ball release) during a shooting motion. The participants had to perform a basketball-related response action to either shots or shot fakes. Response accuracy, response time, and decision confidence were recorded along with gaze behaviour. Anticipation accuracy was reduced at later occlusion points for fake shooting actions. For expert athletes, this effect occurred at later occlusion points compared to novices. The gaze analysis of successful and unsuccessful shot anticipations revealed more gaze fixations towards the hip and legs in successful anticipations, whereas more fixations towards the ball and the head were found in shots unsuccessfully anticipated. It is proposed that hip and leg regions may contain causal information concerning the vertical trajectory of the shooter and identifying this information may be important for perceiving genuine and deceptive shots in basketball.

Keywords: gaze behaviour; eye-tracking; shot fakes; perceptual anticipation

1. Introduction

Perception of information arising from bodily movement is important for anticipating outcomes of actions in sports. Results from previous studies have indicated that experts have a superior ability to anticipate outcomes based on movements of their teammates and/or opponents (e.g., Brault et al., 2012; Cross et al., 2006). This superiority is based on both motor (e.g., Cañal-Bruland et al., 2010) and perceptual expertise (e.g., Brault et al., 2012; Wright & Jackson, 2014) in the specific movements observed (for a review on anticipation in striking sport, see Müller & Abernethy, 2012). The perception of the kinematic properties of the action appear to provide reliable information to predict action outcomes of an athlete (Ward & Williams, 2003). To understand how the information is picked up and processed, gaze behaviour in sports has been examined across a broad range of sporting movements (e.g., Hüttermann et al., 2018). Most eye-tracking studies have investigated different gaze behaviours of the shooter when executing a shot in basketball. However, anticipation is only one side of the athlete opponent interaction. Deceptive behaviour is used to negate the advantage of anticipation. Despite this, there is only limited knowledge about relevant information sources used to predict shot behaviour in the presence of deception (Aglioti et al., 2008; Güldenpenning et al., 2017).

Shot fakes are frequently observed and studied in a range of sports like soccer (deceptive penalty kicks: Smeeton & Williams, 2012), team handball (faked penalty throws: Cañal-Bruland and Schmidt, 2009; Cañal-Bruland et al., 2010), and beach-volleyball (smash feint: Güldenpenning et al., 2013). In basketball, a shot fake can be seen as a deceptive action where an offensive player initiates cues that a defender would expect to see prior to making a shot, but the shooting action is not completed (Gandolfi, 2009; Meyer at al., 2022b; Oliver, 2004). Because the success of a shot fake is determined by the defender perceiving the attackers' shot to be genuine (at least to some degree), examination of the defenders' anticipation behaviour could reveal insights about the information that causes deceptive shots to be misperceived as genuine. Analyses of experts' and novices' gaze behaviour data in such a task may reveal the location of the relevant areas conveying genuine and shot fake information. Therefore, the objective of this study was to examine sources of deceptive information during the anticipation of shot fakes in basketball.

The kinematic specification of dynamics principle (Runeson & Frykholm, 1983) states that dynamic properties of an actors' movement can be perceived through kinematic information. When applied to anticipation behaviour in sports, the perception of the kinematic information can be used to reliably predict action outcomes of an athlete (Ward & Williams, 2003). Furthermore, Runeson and Frykholm (1983) concluded that kinematic information contains sufficient information to allow one to distinguish between an attempt to deceive and a genuine movement. Further studies have shown that only a few key points of light representing joint centres of the body allowed the intent of a movement to be predicted (Abernethy et al., 2001). Thus, there is minimal, yet essential information contained in the kinematic properties of an action. The underlying principle is that over time, people learn to distinguish between task-relevant and task-redundant information and discard task-irrelevant information (Ward & Williams, 2003; Williams et al., 2006, 2009).

As demonstrated across many sports and different experimental settings, experts can read motor cues of a movement earlier and more precisely than novices (Abernethy et al., 2001; Savelsbergh et al., 2002; Williams et al., 2009). When required to, expert players are more accurate than novices at anticipating outcomes at earlier time points (Causer et al., 2017). When they are unconstrained they may wait significantly longer to respond than novices before making their decision (Brault et al., 2012; Cañal-Bruland & Schmidt, 2009). Experts may initiate their response later to maximise the opportunity to pick up more information about the intention of a movement (Mann et al., 2007).

The superior anticipation of experts (Cross et al., 2006; Fadiga et al., 2005) has partly been attributed to motor expertise in the specific movements (Aglioti et al., 2008; Cañal-Bruland et al., 2010) and partly attributed to perceptual expertise (Brault et al., 2012; Dicks et al., 2010; Henry et al., 2012, Wright & Jackson, 2014). According to Mann et al. (2007), perceptual expertise is characterised by efficient processes, i.e. by directing attention to critical time points or body locations, extracting more information from each eye gaze fixation, and ignoring irrelevant sensory signals to reduce the processing demands. In contrast, novices tend to saccade from one fixation to another more frequently and thus, are less able to process the relevant information in time (Mann et al., 2007).

Researchers have attempted to identify the sources of information that support anticipation in a wide range of movements and sports (for a review, see Hüttermann et al., 2018 or Kredel et al., 2017) including tennis (Fukuhara et al., 2017), football (Causer et al., 2017; Savelsbergh et al., 2002), cricket (Croft et al., 2010), handball (Bourne et al., 2013), rugby (Mori & Shimada, 2013), and ice hockey (Panchuk & Vickers, 2006). In striking and throwing actions, one important body region for information extraction in skilful anticipation is thought to be located in the proximal sequence of the kinetic chain (Müller et al., 2010). Gaze directed to the movement pattern of the trunk in relation to the hip can be used to gather information about the subsequent movement. Regarding the end effector, more distal information is only used to confirm the anticipation based on proximal cues (Fukuhara et al., 2017; Hayes et al., 2007; Hodges et al., 2005; Ward et al., 2002). However, the study by Causer et al. (2017) showed that experts do not necessarily need a relative movement between body parts to precisely predict the resultant action.

The majority of the current literature into anticipation skill focuses on actions that have a large lateral rotation such as tennis serves and forehands (e.g., Smeeton & Huys, 2011), handball throws (Cañal-Bruland et al., 2010), penalty kicks in soccer (e.g., Smeeton

& Williams, 2012), and penalty flicks in field hockey (e.g., Morris-Binelli et al., 2021). As such, the hypothesised proximal to distant sequencing of cues may be limited to these types of tasks. Relatively few studies have investigated the information for anticipation in other types of discrete actions such as shots and shot fakes in basketball. In this team sport, the knowledge about the source of information for defending a shooting movement is limited because most eye-tracking studies have only investigated different gaze behaviours of the shooter (van Maarseveen & Oudejans, 2018) and these are usually undertaken without the presence of a defender (Oliveira et al., 2008; Ripoll et al., 1986; Vickers, 1996).

A recent study by Meyer et al. (2022a) investigated the defensive gaze behaviour of skilled and less-skilled basketball players in one-on-one situations. Suggestions of expert coaches regarding defensive gaze behaviour were compared to the gaze behaviour of the players. The gaze behaviour was measured in a field experiment with mobile eye-tracking devices during three phases of an attacking sequence for the predetermined gaze zones (head, ball, torso, and feet). Players are usually instructed to look at the opponent's upper body in order to be insusceptible to fakes. However, the findings of this study suggest that the gaze behaviour of experienced and novice players is suboptimal for information intake in anticipatory defence. Experienced players mainly fixated on the head and novice players primary on the ball (Meyer et al., 2022a).

To counteract anticipation in complex invasion games, such as basketball, offensive players use deception (Argiriou et al., 2014). Reacting to a shot fake can have negative consequences for a defender (Gandolfi, 2009; Oliver, 2004). While the superiority of experts over novices in detecting pass fakes has been shown in a video-based study by Sebanz and Shiffrar (2009), a more recent study by Meyer et al. (2022b) showed that the use of shot fakes in elite level basketball (NBA) is not only highly successful in deceiving the opponent (78%), but is also an effective way to gain an advantage over an opponent. If an attacker performs a shooting motion, the defending player's reaction must be timed according to that motion to be able to impede the shot (Gandolfi, 2009). A shot fake is used to make a defender execute a jumping action, in an attempt to block the shot, which affords the attacker the time to drive the ball into the basket while the defender is still in the air (Hopla, 2012; Krause et al., 2019).

In the coaching science literature, it is noted that the success of a shot fake depends on the game situation respectively the fake is executed in. The normal shooting movement should be maintained (Abdul-Jabbar, 2009; Hopla, 2012; Krause et al., 2019). However, there are various guidelines in the literature for the endpoint position of the ball for a shot fake (Hopla, 2012; Wissel, 2009). To get the defender to wrongly anticipate a shot, players are recommended to use their head and the ball (Güldenpenning et al., 2020; Wooden & Nater, 2006). This guidance is useful when trying to recreate representative tasks and highlight potential body regions, events, and contexts that may be important in deceiving an opponent.

In this study, we aimed to identify expert (gaze) behaviour that is associated with deceptive shot fakes. Visual behaviour and anticipation performance of expert and novice basketball players when defending against genuine and faked basketball shots were compared. In accordance with Sebanz and Shiffrar (2009), we hypothesised that experts can predict the intention of the ensuing movement more accurately than novices. Higher accuracy and confidence rates were predicted for expert players compared to novices (Causer et al., 2017; Müller & Abernethy, 2012). Furthermore, we expected experts to be less susceptible to deceptive actions than novices and that decision confidence in deceptive actions would be greater than genuine actions (Jackson et al., 2006; Smeeton et al., 2012). We expected a greater number of fixations to be located on body location proximal to the dominant axis of rotation in the shot sequence such as legs, hips, and trunk particularly when anticipation was successful regardless of the presence of shot fakes (Meyer et al., 2022a).

2. Method

2.1 Participants

Based on previous research examining deceptive decision making in sport (Güldenpenning et al., 2020; Henry et al., 2012), a minimum sample size of $n = 28$ ($n = 14$ per expertise group) was calculated using G*Power (Faul et al., 2009). This calculation was based on the interaction effect of group and the within-subjects factor stimuli-type (fake vs. non-fake) on response time in the previous studies to achieve a power of .99, having a median effect size (η^2) of .18, a correlation between repeated measures of .50, and an α-value of .05.[1]

In total, 31 adult participants (6 female, 25 male) divided into novices (16) and experts (15) participated in the study. On average, the participants were 23.00 years old (*SD* = 3.13), with a mean age of 24.25 years (*SD* = 2.57) for the novices and 21.67 years (*SD* = 3.33) for the experts. Four participants were left-handed, and the average height was 181.39 cm (*SD* = 11.37 cm).

According to Swann et al. (2015), experts can be categorised based on their performance/participation in national and international competitions, their experience at a certain level of competition, and/or their participation in talent development programmes, among others. Therefore, the participants who served as the experts were playing in the highest national youth league (U-19) for professional basketball or in the second-highest German league (ProA, ProB), during the time of the data collection, and all of them had

[1]We acknowledge that this calculation does not accurately correspond to our 2x2x3 ANOVA design. Since there are no effects for similar deception studies reported so far, we use the existing data as a guide for this calculation (2x2 interaction effect). Moreover, a power analysis with the number of measurements of 3 (occlusion points) or 6 (2 shot type x 3 occlusion points) would lead to smaller sample size (n = 22; n = 14).

participated in national talent development programmes before. For experts, the average playing experience was 9.42 years (*SD* = 4.01).

The novices were sports students who had a general understanding of basketball, but had never played organized basketball at a professional or semi-professional level before. In total, eleven novices were playing at a competitive level (at the time of data collection) in a broad range of sports with an average experience in their sport of 13.67 years (*SD* = 4.87). Five novices did not disclose their sport or had already retired from club-level sports. All participants had normal or corrected to normal vision, no psychological impairments, and had not participated in a similar experiment before. The study was carried out in accordance with the Helsinki Declaration of 1975 and written informed consent was obtained from each participant before testing. Approval was obtained from the ethics committee of the lead researcher's institution (132/2019).

2.2 Design and Materials

We examined the effects of two different *shot types* (shot vs. shot fake), occluded at three *times of occlusion* (-160ms, -80ms, 0ms to ball release) that corresponded with key events in the action sequence (the head fake, ball fake, and high shot fake), on the anticipation performance of experts and novices. We measured the dependent variables *accuracy* (proportion of correct responses), *response time* (in hundredths of a second) as performance indicators, and *confidence* (scale range 1-10). Furthermore, the gaze behaviour of the participants was recorded as a proportion of fixation per gaze areas to assess correlations with anticipatory behaviour. The gaze areas were selected and created from the area of interest in accordance to previous literature on defensive gaze behaviour in basketball: ball, head, upper body, hip, and legs (Meyer et al., 2022a).

For stimulus production, four right-handed adult male basketball players were selected to take the shots. Because the motor experience of the person faking seems to be influential in the success rate of the fake (Brault et al., 2012; Jackson et al., 2006), the shooters filmed were experienced players (>10 years playing experience) and were playing in the highest German national youth league. After a practice period, the players were asked to perform catch-and-shoot movements with a 3-step run-up to the basket (Figure 1, “S”). The attackers were instructed to only look at the basket during the shooting action. This was done in order to standardise eye gaze as an advance cue. The players started their approach to the ball from a standardised position, equidistant from the right and left corner of the free-throw line. The shooter was moving to the location on the court from where a shot happens frequently, requiring a defensive action to impede the shot (Figure 1). The experimental footage was captured with a digital video camera (Lumix DMC-FZ1000EG, Panasonic, Japan) placed at a position parallel to the free-throw line towards the defending team’s basket. The camera angle was devised to replicate the viewing perspective of the defender in the ‘help-side defence’, placed at eye level at 1.80 m at 3 m distance sampling at 25 Hz (Figure 1, “D”). The shot sequences were edited (Adobe Premiere, Adobe, USA) to create three occlusion conditions.

In line with previous research, each video stopped at one of three different occlusion points in the kinematic sequence (Müller et al., 2010; Smeeton & Williams, 2012). It is unclear what kinematic information distinguishes a basketball shot from a fake and at what time point during the movement can this information be found (Hopla, 2012; Wissel, 2009). For this reason, three different shot-fake conditions imitating shooting movements were created. Based on previous research on gaze behaviour/head fakes (e.g., Güldenpenning et al., 2017), a head fake condition was included. In the chronological order of the shot movement in basketball, this was followed by a ball fake and a high shot fake condition.

In the videos, each of the four different shooters performed one *shot* and three different *shot fakes*, including the above-mentioned *head fake*, *ball fake*, and *high shot fake*.

The genuine shot action was performed like a real shot in a game and temporally occluded in the kinematic sequence to end analogously after the three shot deceptions. The videos were occluded just before the ball was lifted from the triple threat position (approx. -160 ms before ball release – Ball Low), when the ball was lifted and reached head height (approx. -80 ms before ball release – Ball Head), and at the release of the ball towards the shot (the highest point of the ball – Ball Release). Fake shot actions were performed at the same time of occlusion, with a head fake (at Ball Low), a ball fake (at Ball Head), and a high shot fake (at Ball Release). The endpoints of the video stimuli and shooting movements are presented in Figure 2.

The complete shot movements in the test videos presenting different shot types were identical in their number of frames. Thus, the genuine shot and fake shot versions of each of the three occlusion points did not differ in their overall length and started at the same time point in relation to ball release. The trials were evenly distributed between the two shot types, the three occlusion points, and the four different players. Shot fakes and shots were presented in a randomised order with 36 trials for each shot type.

The gaze behaviour of each participant was recorded using the Pupil Core mobile eye-tracking system (Pupil Labs GmbH, Berlin, Germany; Kassner et al., 2014). The mobile eye-tracking headset was connected to a laptop (Dell, Latitude 5410, Round Rock, USA) with a USBC-USBC cable. The front camera recorded each participant's first-person view at 30 frames per second (fps), while the pupil cameras recorded at 120 fps. The analysis of the gaze behaviour measured in fixations ($\geq$ 100 ms) was conducted using Pupil Player (version 1.15, Pupil Labs GmbH, Berlin, Germany; Kassner et al., 2014). Reference markers were included in the videos to automatically detect body areas for each shooter. For the analysis of the videos, the player representation was divided into five different areas of interest. In line with Ward et al. (2002) as well as Causer et al. (2017), the differentiation was made between the ball, head, upper body, hip, and legs (see Figure 3). In addition, the time of catching the ball was noted by annotations in the pupil player software, so that the gaze pattern after catching the ball could be analysed precisely.

2.3 Procedure

Before participating in the study, the participants had to sign a participant information sheet and an informed consent form. Additionally, the participants had to answer a paper-based questionnaire asking for personal data such as age, gender, height, handedness, sport, and playing experience.

To replicate the visual angles typically experienced in sports, life-size videos of the players were projected onto a white wall in front of the participants. The video projection was 2.00 m high and 3.55 m wide in a 16:9 ratio; the lower boundary of the projection was 50 cm above the floor. Video sequences (n = 72) with the shooting movement stimuli were presented to the participants, who had to stand in a defensive posture 3 m away from the stimuli. Shot presentation sequence was randomized across all conditions (2 shot types and 3 occlusion points) and lasted 2.30 s (at ball release; minus the respective temporal occlusion) followed by a black screen. A practice test was created in which a total of 9 shots were presented randomly from each of the temporal occlusion points by each player for fake and non-fake shots.

To produce motion responses to defend against a *shot*, the participant had to press a switch above head height. For defending a *shot fake*, the participant had to press a switch around hip height. Touching the switch at head height resembles getting out of your defensive stance and putting a hand in the face of the offensive player to impede the shot while hitting the switch at hip height resembles defending the dribble to the basket of the attacking player (Krause et al., 2019; van Gundy, 2009). Once the participant touched the switch, the video was terminated again. The decision as well as the response times of the participants were recorded on the laptop using PsychoPy2 software (Peirce et al., 2019). Subsequently, the participants verbally rated their own decision confidence on the correctness of their response on a scale from 1 (“lowest confidence”) to 10 (“highest confidence”). No feedback about response correctness or response time was given to the participants by the researchers at any point during the experiment. The participants were instructed to act like in a real game with respect to response action and timing. It was explicitly stated that a too late or too early response would be counted as incorrect because it would not impede the shot or the dribble of the attacker in a real game.

Before the actual testing was done, an eye-tracker calibration was conducted equally for all the participants using the Manual Marker Calibration (Kassner et al., 2014). The two pupil cameras of the eye-tracker had to be configured to record the full scope of the movement of the pupil in all directions. During the calibration phase, all the participants looked at the same five reference markers that were included in a PsychoPy routine (Peirce et al., 2019). The markers were shown in each corner and in the centre of the projected area for 5 seconds to ensure the calibration for the whole video. The calibration was controlled during the experiment by using a fixation cross before every trial.

2.4 Data Analysis

Anticipation behaviour: To reject missed trials, an exclusion criterion with a cut-off value for trials with a response time outside the 95 % confidence interval was applied. Therefore, 42/2,232 trials with a response time between ≤ 0.24 s or ≥ 4.56 s were excluded from the analysis ($M_{rt} = 2.40$, $SD = 1.10$, 95 %-CI [0.24–4.56]). The response time, response correctness as well as confidence values of 2,190 trials from 31 participants were included in the study.

Because a too early or too late response would neither impede the shot nor the dribbling of the attacker in a real game, a response time window between 1 second (ball reception) and 3 seconds (0.70 seconds after ball release) was applied to all the 2,190 included trials. Responses that occurred earlier than the response time window could, therefore, not be attributed to the anticipation of the shooting movement. Responses that occurred later than 3 seconds would not have influenced the shooting motion in a real game and thus, the success of the shot. This was used to ensure representative standards simulating real games, where, to affect the shooter, the action by the defender must accordingly be taken in a timely fashion (Fleming, 2014). Therefore, all the responses made outside the representative response time window were recorded as incorrect. In total, 178 responses were made outside the response time window and, therefore, included in the analysis as incorrect.

The effects of the independent variables *shot type* (shot vs. shot fake) and *times of occlusion* (Ball Low, Ball Head, Ball Release) on the dependent variables *accuracy* (proportion of correct responses), *response time* (in hundredths of a second), and *confidence,* were calculated in a 2 x 2 x 3 repeated measures ANOVA with the group variable *expertise* (experts vs. novices). All response variables were approximately normally distributed, as assessed by the Shapiro-Wilk test (accuracy: $p = .98$; response time, $p = .56$; confidence, $p = .87$). Differences were assessed in Bonferroni-corrected post-hoc analyses. Effect sizes were assessed in eta-squared (η^2) and interpreted in line with Cohen (1988). Thus, a small effect size is found at $\eta^2 = 0.01$, a medium effect size is found at $\eta^2 = 0.06$, and a large effect size is found at $\eta^2 = 0.14$.

Gaze behaviour: The exclusion criterion for pupil detection was set with a confidence threshold of .80 (Picanço & Tonneau, 2018). In line with Dalrymple et al. (2018) and Holmqvist et al. (2012), an outlier threshold for accuracy and precision measures was applied at 1.50°. Only participants for whom at least 8 of the 12 trials in the respective condition (≥ 66 %) contained sufficient gaze data, were considered, resulting in a total of 1,440/2,190 trials from ten experts and ten novices included in the analysis of gaze behaviour. The eye-tracking data showed a mean accuracy result of 1.01° (*SD* = 0.23), and a mean precision result of 0.10° (*SD* = 0.02). The effects of the independent variable *gaze areas* (head, ball, upper body, hip, legs) and the group variable *expertise* (experts vs. novices) were calculated with a 5 x 2 repeated measures ANOVA with the *fixations* (proportion of total fixations ≥ 100 ms) entered as the dependent variable. Post-hoc analyses (Bonferroni-corrected) were used to evaluate potential differences vis-à-vis fixated gaze areas. Correlations of gaze behaviour (proportion of fixations per gaze area) and anticipation performance (response accuracy, response time, and confidence) were assessed and the correlation coefficient r was interpreted in line with Cohen (1988). Thus, a weak association is found at $r = 0.10$, a moderate association at $r = 0.30$, and a strong association at $r = 0.50$.

3. Results

3.1 Anticipation behaviour

Accuracy: Accuracy data is plotted in Figure 4 and 5. Overall, the three-way interaction effect of expertise, shot type, and occlusion on accuracy (Figure 4) was found to be non-significant, $F(2,58) = 0.15$, $p = .86$, $\eta^2 = 0.01$.

A significant interaction effect of occlusion and shot type (Figure 5) was found with a large effect size, $F(2,58) = 26.34$, $p < .01$, $\eta^2 = 0.48$. When responding to shot fakes, post-hoc analyses revealed significantly higher accuracy for head fakes (M_{occ1} = 46.90 %, SD = 19.48 %) and ball fakes (M_{occ2} = 41.80 %, SD = 18.93 %) compared to high shot fakes (M_{occ3} = 24.30 %, SD = 14.47 %), $F(2,28) = 22.64$, $p < .01$, $\eta^2 = 0.62$. No difference was found between ball fakes and head fakes ($p = .48$). When responding to shots, post-hoc analyses revealed significant differences in accuracy between all three times of occlusion: Ball Low (M_{occ1} = 45.50 %, SD = 18.37 %), Ball Head (M_{occ2} = 56.20 %, SD = 15.59 %), and Ball Release (M_{occ3} = 69.90 %, SD = 21.16 %), $F(2,28) = 9.31$, $p < .01$, $\eta^2 = 0.40$.

A significant interaction effect was found for shot type and expertise on accuracy with a large effect size, $F(1,29) = 4.94$, $p = .03$, $\eta^2 = 0.15$. Post-hoc tests showed significantly higher accuracy for experts ($M_{exp} = 44.20$ %, $SD = 13.94$ %) over novices, ($M_{nov} = 31.10$ %, $SD = 14.00$ %) when responding to shot fakes with a large effect size, $F(1,29) = 6.85$, $p = .01$, $\eta^2 = 0.19$. No significant difference was found when responding to genuine shots between experts and novices ($p = .94$).

Overall, experts ($M_{exp} = 50.60$ %, $SD = 9.68$ %) did not have significantly better accuracy than novices ($M_{nov} = 44.20$ %, $SD = 9.60$ %), $F(1,29) = 3.38$, $p = .08$, $\eta^2 = 0.10$ (Figure 6).

Response time: No significant interaction effects were found on response time. However, a significant main effect of occlusion was detected with a large effect size, $F(2,58) = 5.56$, $p = .01$, $\eta^2 = 0.16$. Post-hoc analyses identified significantly earlier responses at Ball Release ($M_{occ3} = 2.27$ s, $SD = 0.24$ s) compared to Ball Head ($M_{occ2} = 2.33$ s, $SD = 0.28$ s) with a large effect size, $F(1,29) = 6.35$, $p < .01$, $\eta^2 = 0.31$. No significant differences were found for Ball Low ($M_{occ1} = 2.32$ s, $SD = 0.32$ s) in relation to Ball Head ($p > .99$) and Ball Release ($p = .11$).

Furthermore, the main effect of expertise on response time ($M_{exp} = 2.43$ s, $SD = 0.27$ s; $M_{nov} = 2.21$ s, $SD = 0.28$ s) was found to be non-significant with a medium effect size, $F(1,29) = 3.68$, $p = .07$, $\eta^2 = 0.11$.

Confidence: No significant interaction effects were found on confidence. A significant main effect of shot type was found with a large effect size, $F(1,29) = 9.42$, $p = .01$, $\eta^2 = 0.25$. Post-hoc analyses revealed significantly greater confidence responding to the videos presenting shot fakes ($M_{fake} = 7.39$, $SD = 0.80$) than to the videos showing genuine shots ($M_{shot} = 7.16$, $SD = 0.94$).

Furthermore, a significant main effect of occlusion (Figure 7) was found with a large effect size, $F(2,58) = 26.73$, $p < .01$, $\eta^2 = 0.48$. Post-hoc analyses revealed significant ($p < .01$) differences between all three times of occlusion, with progressive increase in confidence to later times of occlusion: Ball Low ($M_{occ1} = 6.87$, $SD = 1.04$), Ball Head ($M_{occ2} = 7.19$, $SD = 0.90$), and Ball Release ($M_{occ3} = 7.77$, $SD = 0.86$).

The analysis of response confidence observed a significant main effect of expertise with a large effect size, $F(1,29) = 11.46$, $p < .01$, $\eta^2 = 0.28$. As presented in Figure 8, post-hoc analyses found significantly greater confidence of experts ($M_{exp} = 7.78$, $SD = 0.85$) over that of novices ($M_{nov} = 6.76$, $SD = 0.85$).

3.2 Gaze behaviour

The interaction of gaze area and expertise was found to be non-significant on the fixations, $F(4,72) = 0.411$, $p = .80$, $\eta^2 = 0.02$. The main effect of gaze area on fixations was assessed as significant with a large effect size, $F(4,72) = 19.337$, $p < .01$, $\eta^2 = 0.52$. Pairwise comparison showed more fixations ($p < .01$) on the head ($M_{head} = 42.42$ %, $SD = 5.73$ %) than on the ball ($M_{ball} = 14.86$ %, $SD = 2.36$ %), hip ($M_{hip} = 9.45$ %, $SD = 2.56$ %), and legs ($M_{legs} = 2.46$ %, $SD = 0.56$ %), though not compared to the upper body ($M_{upper\ body} = 30.78$ %, $SD = 3.13$ %). The upper body attracted a significantly ($p < .01$) higher proportion of fixations than the ball, hip, and legs. Further, the ball was fixated significantly ($p < .01$) more often than the legs.

3.3 Exploratory analysis

Correlation between gaze behaviour and accuracy: Correlation data for accuracy and gaze behaviour (in proportion of fixations per gaze area) is presented in Table 1. Overall, the results showed significant positive correlations to gaze on the hip, $r = .48$, $p = .03$, and on the legs with medium effect sizes, $r = .50$, $p = .03$. In contrast, a significant negative correlation was detected between the proportion of fixations on the ball and accuracy with a large effect size, $r = -.57$, $p = .01$. The more a participant fixated on the legs and hips, the more accurate the response was. On the contrary, more frequent fixations on the ball seem to be associated with poorer anticipation accuracy.

Experts showed a negative but non-significant correlation between accuracy and proportion of fixations on the head with a large effect size, $r = -.55$, $p = .10$, and a positive but non-significant correlation when looking at the hip with a large effect size, $r = .60$, $p = .07$. Novices demonstrated a positive, but non-significant correlation between accuracy and fixations on the legs with a large effect size, $r = .57$, $p = .09$.

When showing a head fake (shot fake occluded at Ball Low), a significant negative correlation was found for accuracy and fixations at the head with a large effect size, $r = -.61$, $p < .01$. For novices, this negative correlation was found to be significant with a large effect size, $r = -.85$, $p < .01$, while experts showed a negative but non-significant correlation with a large effect size, $r = -.52$, $p = .13$. These results showed that a higher proportion of fixations on the head correlates with a lower anticipation accuracy of head fakes by the defender, especially in novices, but evidently, also in experts.

Correlation between gaze behaviour and response time: A significant positive correlation was shown between the proportion of fixations on the hip and response time with a medium effect size, $r = .44$, $p = .05$. This result suggests that the participants who were fixating on the hip, more often responded later to the task.

Correlation between gaze behaviour and confidence: A significant negative correlation between the proportion of fixations on the ball and confidence was revealed with a large effect size, $r = -.54$, $p = .02$. For the same gaze area, novices demonstrated a significant negative correlation with a large effect size, $r = -.68$, $p = .03$, while experts showed a negative, but non-significant correlation with a medium effect size, $r = -.31$, *p* = .38. The results showed that a higher proportion of fixations on the head lead to lower confidence in the given response, particularly evident in novices.

4. Discussion

This study investigated the visual behaviour and anticipation performance of expert and novice players when defending against genuine and faked basketball shots. In line with our predictions, the accuracy for both experts and novices was lower for the shot fakes than for the genuine shots, whilst confidence was greater in the shot fakes compared to genuine shots. Furthermore, accuracy at anticipating fake shots reduced across the three points of occlusion in the action sequences, suggesting shots became more deceptive as the shooting action reached its end point and this effect was more pronounced in experts. More specifically, the significant interaction effects of occlusion and shot type on accuracy showed that the anticipation accuracy of shot fakes decreased with later occlusion, while the significant main effect of occlusion on confidence indicated an increased confidence in giving the correct answer in the later occlusion conditions. For novices, a deterioration of accuracy was found between all three fakes with progressing occlusion. Experts showed lower accuracy for high shot fakes and were only more accurate than novices defending ball fakes (Figure 9). These findings are in contrast to others who found that as actions evolved participants were less likely to be deceived (e.g., Causer et al., 2017; Mori & Shimada, 2013; Smeeton et al. 2012). Participants in this study had to choose between different classes of action, either defending the subsequent dribble or jumping/stretching to block the shot, which is contrary to other studies that have used a left-right response (e.g., Warren-West & Jackson, 2020).

What appears to be critical is the timeliness of a response in the evolution of the action towards its completion. In typical anticipation skill paradigms, a left-right decision has to be made, where an early decision may not influence the subsequent action of an opponent. Arguably, in tasks that are more representative to the constraints experienced by sportspeople, there are critical time periods in which they must respond, otherwise an opponent may prevent or reverse an intended action, or complete it unopposed. In this particular basketball task, the endpoint of the shot fake occurs late in the shooting action (i.e., high shot fake) and its presence leads to participants being deceived more often. Additionally, experts responded later in the action than novices. One may speculate that a critical response window that occurs late in the action results in biomechanical constraints being imposed on the defensive player. The jump/stretch to intercept a shot requires a vertical force to be generated in time to the shot release of the offensive player. If the defender incorrectly anticipates a shot to be genuine then the momentum generated by this vertical force introduces a time delay to reverse this course of action.

Our prediction regarding the eye movement data was partially contradicted. It was predicted that a greater number of fixations would be found on the body location proximal to the shot sequence. The findings here showed considerably more fixations on higher body parts (upper body and head; combined 73 % of all fixations), than on the lower body region (hip and legs; combined 12 %). However, fixation of the ball, although unlikely to provide kinematic information, accounted for an average of 15 % of fixations. These results are consistent with the findings of previous studies, but are in contrast to the coaches' recommendations (Meyer et al., 2022a).

Contrary to our predicted effects of gaze behaviour no significant differences in eye movements were seen between skill levels. As a consequence, we undertook exploratory correlations between gaze parameters and the performance measures taken. These measures showed that participants who spent longer fixating on the hips and legs were more successful at the task, while those that spent longer fixating on the ball and head were less successful. Subgroup analysis of the novices showed a significant negative relationship between fixations on the head and accuracy when viewing head fake shots. It is more important to note that the majority of the significant positive and negative correlations with accuracy are limited to the earliest time of occlusion. Here, accuracy was higher in trials with shot fakes than at a later occlusion time, which was reversed for genuine shots, where the correlation coefficients were not as strong. These findings support previous studies that have shown that gaze orientated towards regions proximal to the end effector is important for anticipation (Smeeton et al., 2019; Ward & Williams, 2003; Williams et al., 2009). However, here we show that these gaze patterns are important for actions that do not rotate to such a degree around the vertical axis. There was also evidence for the critical response time occurring later in the action, where a positive relationship was found between response time and the proportion of gaze time fixated on the hips. Finally, gaze directed towards the head was associated with a lower confidence rating. The results of the gaze analyses suggest that fixating the gaze at the hip and legs was the most effective strategy when trying to distinguish between shot and shot fake. This fixation location may reflect a gaze 'anchoring' strategy from which information for anticipation is extracted (Vater et al., 2020). This fixation point may be an efficient way to extract the essential kinematic information specifying the dynamic properties of the action (Runeson & Frykholm, 1983). The kinematics of the shot-fake movements might further explain the vulnerability of experts when anticipating the high shot fake, as the key partial movements were closest to a full leg extension. Moreover, the movement of the hip and legs occurred late in the action, contrary to the always-moving ball and early moving head.

These results add to the proposal of expert characteristics in fast-paced ball sports that they respond later to avoid deception and, to compensate for greater time constraints, they use their superior athleticism compared to novices (Dicks et al., 2010). In turn, the results indicate that the key information to correctly anticipate the deceptive movement may be found at a later stage of the motion. Hence, the tendency to respond later might be caused by the experts waiting for the key partial movement according to their motor experience (Aglioti et al., 2008; Cañal-Bruland et al., 2010; Müller & Abernethy, 2012). This may also explain the finding that all three shot fakes often deceived defenders that looked at the ball. This finding suggests that the phenomenon of the delayed deception effect on expertise could be related to a perceptual strategy. In accordance with the literature and our findings, experts tend to focus on the task-relevant areas, subsequently leading to the assumption that the effect may be motion-specific in correspondence to the timing of the relevant movement. A motion with a late-moving relevant area could potentially enhance the effect, while a motion with an early-moving relevant area might impair the effect.

Based on the results of this study, future investigations could further investigate behaviour of expert anticipation in deceptive movements, specifically with regard to timeliness of the movement. It may be suitable to point out that recent studies using temporal and spatial occlusion have shown how accuracy data from both the genuine and deceptive trials can be used to calculate a single measure of the ability to discriminate between genuine and deceptive actions (Jackson et al., 2018, 2020).

4.1 Limitations

Some limitations need to be considered when discussing the results of this study. Even though female participants were included in the study ($n_{exp} = 2$; $n_{nov} = 4$; eye-tracking analysis: $n_{exp} = 2$; $n_{nov} = 2$), the shooters represented in the stimuli were only male basketball players. The analysis of the pre-test evaluation and the participants' results showed that it was unlikely that gender had a decisive influence on the results[2].

[2] t-test to examine gender-based accuracy differences: $t(29) = 0.65$, $p = .52$, $d = 0.30$; eye-tracking analysis: $t(18) = 0.97$, $p = .34$, $d = 0.54$.

It is noteworthy that the participants may have changed their original decision during the response time. This would result in a change in movement with an increased response time. Controlling the response time window for each sequence, therefore, was designed to ensure that most of these cases were classified as incorrect decisions because the change in the initial response would largely have prevented timely responses by the participants.

A high threshold for gaze data quality was set to improve reliability of the data[3]. This meant that confidence in detecting the pupil was increased and deviations in fixation point placement were reduced. This step was necessary because the participants were actively moving at all times of the experiment. It, however, did result in a smaller number of participants and trials being included in the gaze behaviour analysis, which must be acknowledged when interpreting the gaze results.

5.2 Practical application

The results may have practical value for those wishing to develop expertise in basketball. The results suggest an approach for the coaches to guide gaze towards the hip and legs of the attacker in a shooting situation may help players become resistant to deception. This was also highlighted by the finding that more fixations on the ball movement decreased the chances of accurate anticipation and decreased the confidence in the response. Thus, the participants were able to notice the absence of relevant information, which suggests that the gaze strategy may be trainable through internal feedback. While research has indicated that perceptual recognition of deception is trainable (Ryu et al., 2018), a deeper analysis of this phenomenon might be required.

From an offensive point of view, our results underline that a high shot fake with a long kept genuine shooting motion might be the most deceiving. Coaches can use this finding

[3] Pupil detection was set with a confidence threshold of .80 and an outlier threshold for accuracy and precision measures was applied at 1.50°.

to instruct their players to use the high shot fake to increase the effectiveness of shot fakes. Because defenders require a degree of extension of the leg and hips to intercept this shot, it limits the defenders' opportunity to reverse this defensive response and action to defend and attackers subsequent dribble. However, further studies such as a frequency analysis of shot fakes in professional games or a replicational field experiment are needed to provide more insights into whether these shot fakes are effective from the attacker's perspective.

5. Conclusions

In conclusion, our findings suggest that critical time windows for anticipation exist. Deception can me more effective when the action is reversed or inhibited towards the end point of the action. Gaze behaviour results indicate that the key information to correctly anticipate the deceptive movement can be found at a later stage of the shooting motion and accurate perception of motion patterns in the legs and hips may be used to determine if a shot will be executed. Timely gaze guided towards the hip and legs of the attacker in a shooting situation in basketball may facilitate anticipation performance.

Disclosure Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

Raw data was generated at the German Sport University Cologne. All the data supporting the findings of this study is available from the corresponding author (JM) on request.

References

Abdul-Jabbar, K. (2009). Post Moves. In G. Gandolfi (Ed.), *NBA coaches playbook: Techniques, tactics, and teaching points*. Human Kinetics.

Abernethy, B., Gill, D. P., Parks, S. L., & Packer, S. T. (2001). Expertise and the perception of kinematic and situational probability information. *Perception*, *30*(2), 233–252. https://doi.org/10.1068/p2872

Aglioti, S. M., Cesari, P., Romani, M., & Urgesi, C. (2008). Action anticipation and motor resonance in elite basketball players. *Nature Neuroscience*, *11*(9), 1109–1116.

Argiriou, M., Rousanoglou, E., Boudolos, K., & Bolatoglou, T. (2014). The role of preceding technical and tactical skills on jump shot accuracy in male and female basketball players. *Journal of Athletic Enhancement 3*(4), 2. http://dx.doi.org/10.4172/2324-9080.1000157

Brault, S., Bideau, B., Kulpa, R., & Craig, C. M. (2012). Detecting deception in movement: The case of the side-step in rugby. *PloS One*, *7*(6), e37494. https://doi.org/10.1371/journal.pone.0037494

Bourne, M., Bennett, S. J., Hayes, S. J., Smeeton, N. J., & Williams, A. M. (2013). Information underpinning anticipation of goal-directed throwing. *Attention, Perception, & Psychophysics*, *75*(7), 1559-1569.

Cañal-Bruland, R., & Schmidt, M. (2009). Response bias in judging deceptive movements. *Acta Psychologica*, *130*(3), 235–240. https://doi.org/10.1016/j.actpsy.2008.12.009

Cañal-Bruland, R., van der Kamp, J., & van Kesteren, J. (2010). An examination of motor and perceptual contributions to the recognition of deception from others' actions. *Human Movement Science*, *29*(1), 94–102. https://doi.org/10.1016/j.humov.2009.10.001

Causer, J., Smeeton, N. J., & Williams, A. M. (2017). Expertise differences in anticipatory judgements during a temporally and spatially occluded task. *PloS One*, *12*(2), e0171330. https://doi.org/10.1371/journal.pone.0171330

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). L. Erlbaum Associates.

Croft, J. L., Button, C., & Dicks, M. (2010). Visual strategies of sub-elite cricket batsmen in response to different ball velocities. *Human Movement Science, 29*(5), 751-763. https://doi.org/10.1016/j.humov.2009.10.004

Cross, E. S., Hamilton, A. F. d. C., & Grafton, S. T. (2006). Building a motor simulation de novo: Observation of dance by dancers. *NeuroImage*, *31*(3), 1257–1267. https://doi.org/10.1016/j.neuroimage.2006.01.033

Dalrymple, K. A., Manner, M. D., Harmelink, K. A., Teska, E. P., & Elison, J. T. (2018). An examination of recording accuracy and precision from eye tracking data from toddlerhood to adulthood. *Frontiers in psychology*, *9*, 803.

Dicks, M., Davids, K., & Button, C. (2010a). Individual differences in the visual control of intercepting a penalty kick in association football. *Human Movement Science*, *29*(3), 401–411. https://doi.org/10.1016/j.humov.2010.02.008

Fadiga, L., Craighero, L., & Olivier, E. (2005). Human motor cortex excitability during the perception of others' action. *Current Opinion in Neurobiology*, *15*(2), 213–218. https://doi.org/10.1016/j.conb.2005.03.013

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*, 1149-1160.

Fukuhara, K., Ida, H., Ogata, T., Ishii, M., & Higuchi, T. (2017). The role of proximal body information on anticipatory judgment in tennis using graphical information richness. *PloS One*, *12*(7), e0180985. https://doi.org/10.1371/journal.pone.0180985

Gandolfi, G. (Ed.). (2009). *NBA coaches playbook: Techniques, tactics, and teaching points.* Human Kinetics.

Güldenpenning, I., Kunde, W., & Weigelt, M. (2017). How to trick your opponent: A review article on deceptive actions in interactive sports. *Frontiers in Psychology*, *8*, 917.

Güldenpenning, I., Steinke, A., Koester, D., & Schack, T. (2013). Athletes and novices are differently capable to recognize feint and non-feint actions. *Experimental brain research, 230*(3), 333-343.

Güldenpenning, I., Weigelt, M., Memmert, D., & Klatt, S. (2020). Processing deceptive information in sports: Individual differences for responding to head fakes depends on the attentional capability of the observer. *Psychology of Sport and Exercise*, *51*, 101764.

Hayes, S. J., Hodges, N. J., Huys, R., & Mark Williams, A. (2007). End-point focus manipulations to determine what information is used during observational learning. *Acta Psychologica*, *126*(2), 120–137. https://doi.org/10.1016/j.actpsy.2006.11.003

Henry, G., Dawson, B., Lay, B., & Young, W. (2012). Effects of a feint on reactive agility performance. *Journal of Sports Sciences*, *30*(8), 787–795. https://doi.org/10.1080/02640414.2012.671527

Hodges, N. J., Hayes, S. J., Breslin, G., & Williams, A. M. (2005). An evaluation of the minimal constraining information during observation for movement reproduction. *Acta Psychologica*, *119*(3), 264–282. https://doi.org/10.1016/j.actpsy.2005.02.002

Holmqvist, K., Nyström, M., & Mulvey, F. (2012, March). Eye tracker data quality: what it is and how to measure it. In *Proceedings of the symposium on eye tracking research and applications* (pp. 45-52).

Hopla, D. (2012). *Basketball shooting*. Human Kinetics.

Hüttermann, S., Noël, B., & Memmert, D. (2018). Eye tracking in high-performance sports: Evaluation of its application in expert athletes. *International Journal of Computer Science in Sport*, *17*(2), 182-203.

Jackson, R. C., Barton, H., & Bishop, D. T. (2020). Knowledge is power? Outcome probability information impairs detection of deceptive intent. *Psychology of Sport and Exercise, 50*, 101744. https://doi.org/10.1016/j.psychsport.2020.101744

Jackson, R. C., Barton, H., Ashford, K. J., & Abernethy, B. (2018). Stepovers and signal detection: Response sensitivity and bias in the differentiation of genuine and deceptive football actions. *Frontiers in Psychology*, 2043.

Jackson, R. C., Warren, S., & Abernethy, B. (2006). Anticipation skill and susceptibility to deceptive movement. *Acta Psychologica*, *123*(3), 355–371. https://doi.org/10.1016/j.actpsy.2006.02.002

Kassner, M., Patera, W., & Bulling, A. (2014, September). Pupil: an open source platform for pervasive eye tracking and mobile gaze-based interaction. In *Proceedings of the 2014 ACM international joint conference on pervasive and ubiquitous computing: Adjunct publication* (pp. 1151-1160). http://dx.doi.org/10.1145/2638728.2641695

Krause, J., Nelson, C., & Krzyzewski, M. (2019). *Basketball skills & drills*. Human Kinetics.

Kredel, R., Vater, C., Klostermann, A., & Hossner, E. J. (2017). Eye-tracking technology and the dynamics of natural gaze behavior in sports: A systematic review of 40 years of research. *Frontiers in psychology, 8*, 1845.

Mann, D. T. Y., Williams, A. M., Ward, P., & Janelle, C. M. (2007). Perceptual-cognitive expertise in sport: A meta-analysis. *Journal of Sport & Exercise Psychology*, *29*(4), 457–478.

Meyer, J., Fasold, F., Schul, K., Sonnenschein, M., & Klatt, S. (2022a). The Defender's Vision—Gaze Behavior of One-on-One Defenders in Basketball. J*ournal of Sport & Exercise Psychology*. https://doi.org/10.1123/jsep.2021-0149

Meyer, J., Fasold, F., Schul, K., Schön, T., & Klatt, S. (2022b). Shot fakes as an indicator of successful offense in basketball. *Human Movement Science, 82*, 102920. https://doi.org/10.1016/j.humov.2021.102920

Mori, S., & Shimada, T. (2013). Expert anticipation from deceptive action. *Attention, Perception & Psychophysics*, *75*(4), 751–770. https://doi.org/10.3758/s13414-013-0435-z

Morris-Binelli, K., Müller, S., van Rens, F. E., Harbaugh, A. G., & Rosalie, S. M. (2021). Individual differences in performance and learning of visual anticipation in expert field hockey goalkeepers. *Psychology of Sport and Exercise, 52*, 101829.

Müller, S., Abernethy, B., Eid, M., McBean, R., & Rose, M. (2010). Expertise and the spatio-temporal characteristics of anticipatory information pick-up from complex movement patterns. *Perception*, *39*(6), 745-760.

Müller, S., & Abernethy, B. (2012). Expert anticipatory skill in striking sports: A review and a model. *Research quarterly for exercise and sport, 83*(2), 175-187.

Oliveira, R. F. de, Oudejans, R. R. D., & Beek, P. J. (2008). Gaze Behavior in Basketball Shooting: Further Evidence for Online Visual Control. *Research Quarterly for Exercise and Sport*, *79*(3), 399–404. https://doi.org/10.5641/193250308X13086832906193

Oliver, J. (2004). *Basketball fundamentals. A better way to learn the basics*. Human Kinetics.

Panchuk, D., & Vickers, J. N. (2006). Gaze behaviors of goaltenders under spatial-temporal constraints. *Human movement science*, *25*(6), 733–752. https://doi.org/10.1016/j.humov.2006.07.001

Peirce, J. W., Gray, J. R., Simpson, S., MacAskill, M. R., Höchenberger, R., Sogo, H., Kastman, E., Lindeløv, J. (2019). PsychoPy2: experiments in behavior made easy. *Behavior Research Methods, 51*(1), 195-203. 10.3758/s13428-018-01193-y

Ripoll, H., Bard, C., & Paillard, J. (1986). Stabilization of head and eyes on target as a factor in successful basketball shooting. *Human movement science*, *5*(1), 47–58. https://doi.org/10.1016/0167-9457(86)90005-9

Runeson, S., & Frykholm, G. (1983). Kinematic specification of dynamics as an informational basis for person-and-action perception: Expectation, gender recognition, and deceptive intention. *Journal of Experimental Psychology*: *General*, *112*(4), 585–615. https://doi.org/10.1037/0096-3445.112.4.585

Ryu, D., Abernethy, B., Park, S. H., & Mann, D. L. (2018). The perception of deceptive information can be enhanced by training that removes superficial visual information. *Frontiers in Psychology*, *9*, 1132.

Savelsbergh, G. J. P., Williams, A. M., van der Kamp, J., & Ward, P. (2002). Visual search, anticipation and expertise in soccer goalkeepers. *Journal of Sports Sciences*, *20*(3), 279–287. https://doi.org/10.1080/026404102317284826

Sebanz, N., & Shiffrar, M. (2009). Detecting deception in a bluffing body: The role of expertise. *Psychonomic Bulletin & Review*, *16*(1), 170–175. https://doi.org/10.3758/PBR.16.1.170

Smeeton, N. J., & Williams, A. M. (2012). The role of movement exaggeration in the anticipation of deceptive soccer penalty kicks. *British Journal of Psychology, 103*(4), 539-555.

Smeeton, N. J., & Huys, R. (2011). Anticipation of tennis-shot direction from whole-body movement: The role of movement amplitude and dynamics. *Human Movement Science*, *30*(5), 957-965.

Smeeton, N. J., Hüttermann, S., & Williams, A. M. (2019). Postural cues, biological motion perception, and anticipation in sport. *Anticipation and decision making in sport*, 3-24.

Swann, C., Moran, A., & Piggott, D. (2015). Defining elite athletes: Issues in the study of expert performance in sport psychology. *Psychology of Sport and Exercise, 16*, 3-14.

Van Gundy, S. (2009). Perimeter Moves. In G. Gandolfi (Ed.), *NBA coaches playbook: Techniques, tactics, and teaching points.* Human Kinetics.

Van Maarseveen, M. J. J., & Oudejans, R. R. D. (2018). Motor and Gaze Behaviors of Youth Basketball Players Taking Contested and Uncontested Jump Shots. *Frontiers in Psychology*, *9*, 706. https://doi.org/10.3389/fpsyg.2018.00706

Vater, C., Williams, A. M., & Hossner, E. J. (2020). What do we see out of the corner of our eye? The role of visual pivots and gaze anchors in sport. *International Review of Sport and Exercise Psychology, 13*(1), 81-103. https://doi.org/10.1080/1750984X.2019.1582082

Vickers, J. N. (1996). Visual control when aiming at a far target. Journal of experimental psychology. *Human perception and performance*, *22*(2), 342–354. https://doi.org/10.1037//0096-1523.22.2.342

Ward, P., & Williams, A. M. (2003). Perceptual and Cognitive Skill Development in Soccer: The Multidimensional Nature of Expert Performance. *Journal of sport & exercise psychology*, *25*(1), 93–111. https://doi.org/10.1123/jsep.25.1.93

Ward, P., Williams, A. M., & Bennett, S. J. (2002). Visual search and biological motion perception in tennis. *Research Quarterly for Exercise and Sport*, *73*(1), 107–112. https://doi.org/10.1080/02701367.2002.10608997

Warren-West, L. S., & Jackson, R. C. (2020). Seeing the bigger picture: susceptibility to, and detection of, deception. *Journal of Sport and Exercise Psychology, 42*(6), 463-471. https://doi.org/10.1123/jsep.2020-0040

Williams, A. M., Hodges, N. J., North, J. S., & Barton, G. (2006). Perceiving patterns of play in dynamic sport tasks: Investigating the essential information underlying skilled performance. *Perception*, *35*(3), 317–332. https://doi.org/10.1068/p5310

Williams, M. A., Huys, R., Cañal-Bruland, R., & Hagemann, N. (2009). The dynamical information underpinning anticipation skill. *Human Movement Science*, *28*(3), 362–370. https://doi.org/10.1016/j.humov.2008.10.006

Wissel, H. (2009). Shooting Technique. In G. Gandolfi (Ed.), *NBA coaches playbook: Techniques, tactics, and teaching points.* Human Kinetics.

Wooden, J. R., & Nater, S. (2006). *John Wooden's UCLA offense*. Human Kinetics.

Wright, M. J., & Jackson, R. C. (2014). Deceptive body movements reverse spatial cueing in soccer. *PloS One*, *9*(8), e104290. https://doi.org/10.1371/journal.pone.0104290

Tables

Table 1

Correlation between response accuracy and proportion of fixations per gaze area for fakes and shots per occlusion point

Accuracy vs gaze area	Ball	Head	Hip	Legs	Upper body
Overall	-.107	-.268	.479*	.499*	.063
Fake	.281	.342	.399	.420	-.020
Occl 1	.245	-.608**	.673**	.459*	.253
Occl 2	.172	-.171	.274	.316	-.119
Occl 3	.281	-.081	.039	.234	-.151
Shot	-.571**	.070	.170	.151	.142
Occl 1	-.406	.326	-.155	.134	-.174
Occl 2	-.516*	-.134	.311	.293	.322
Occl 3	-.181	-.134	.241	-.120	.203
Experts	.126	-.551	.597	.232	.348
Fake	.535	-.517	.387	.227	.318
Occl 1	.288	-.516	.646*	.325	.115
Occl 2	.602	-.488	.228	.030	.457
Occl 3	.458	-.256	.042	.160	.223
Shot	-.748*	-.040	.357	-.014	.043
Occl 1	-.257	.341	-.277	-.159	-.230
Occl 2	-.723*	-.306	.511	.250	.346
Occl 3	-.212	-.161	.370	-.059	.030
Novices	.148	-.024	-.346	.568	-.009
Fake	.782**	-.239	.-.091	.111	-.310
Occl 1	.515	-.854**	.715*	.647*	.571
Occl 2	.588	.140	-.327*	-.223	-.622
Occl 3	.444	.149	-.455	-.133	-.464
Shot	-.497	.167	-.185	.322	.235
Occl 1	-.400	.390	-.509	.247	-.081
Occl 2	-.427	.051	-.170	.349	.345
Occl 3	-.317	-.119	.334	.136	.345

Note. * $p < .05$, ** $p < .001$

Figure Captions

Figure 1

Basketball situation replicated in this study: The attacker (S) ran to the free throw line to receive the ball from passer (P). The participant (D) underneath the basket had to defend the shooting player (S). The camera was set up in a static position (D), parallel to the free-throw line, facing the attacker (S) who was always in the picture.

Figure 2

Final frames of the three different occlusion points presented: head fake, ball fake, and high shot fake.

Figure 3

Graphic display of the gaze areas used for the analysis: ball, head, upper body, hip, and legs.

Figure 4

Display of the 3-way interaction of shot type (shot vs. shot fake), expertise (experts vs. novices), and time of occlusion (Ball Low, Ball Head, Ball High) on accuracy (proportion of correct responses).

Note. Error bars represent SD per shot type.

Figure 5

Comparison of the proportion of correct responses (accuracy) for shots and shot fakes (shot type) for the times of occlusion Ball Low, Ball Head, and Ball High.

Note. Significant differences ($p \leq .05$) of accuracy between the shot type for the respective occlusion are marked with *. Error bars represent SD per shot type.

Figure 6

Comparison of overall accuracy (proportion of correct responses) between expertise groups (experts vs. novices) for shot types (shots vs. shot fakes).

Note. Significant differences ($p \leq .05$) are marked with *; Error bars represent SD.

Figure 7

Comparison of mean averages of accuracy, response time, and confidence between experts and novices on shot fakes.

Note. Significant differences ($p \leq .05$) between the groups are marked with *; Error bars represent SD per group.

Figure 8

Comparison of confidence between per time of occlusion (Ball Low, Ball Head, Ball High).

Note. Significant differences ($p \leq .05$) between the times of occlusion are marked with *; Error bars represent SD per time of occlusion.

Figure 9

Mean accuracy of expert and novice players for the times of occlusion Ball Low (head fake), Ball Head (ball fake), and Ball High (high shot fake).

Note. * signals significant difference ($p \leq .05$) between experts and novices. Error bars represent SE per group.