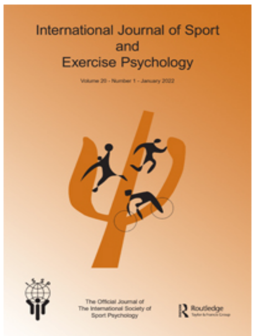

Routledge
Taylor & Francis Group

International Journal of Sport and Exercise Psychology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rijs20

Head-fake perception in basketball: the relative contributions of expertise, visual or motor training, and test repetition

Iris Güldenpenning, Wilfried Kunde & Matthias Weigelt

To cite this article: Iris Güldenpenning, Wilfried Kunde & Matthias Weigelt (2022) Head-fake perception in basketball: the relative contributions of expertise, visual or motor training, and test repetition, International Journal of Sport and Exercise Psychology, 20:1, 202-222, DOI: 10.1080/1612197X.2020.1854819

To link to this article: https://doi.org/10.1080/1612197X.2020.1854819

Published online: 09 Dec 2020.

INTERNATIONAL JOURNAL OF SPORT AND EXERCISE PSYCHOLOGY
2022, VOL. 20, NO. 1, 202–222
https://doi.org/10.1080/1612197X.2020.1854819

Routledge
Taylor & Francis Group

Check for updates

Head-fake perception in basketball: the relative contributions of expertise, visual or motor training, and test repetition

Iris Güldenpenning [a], Wilfried Kunde [b] and Matthias Weigelt [a]

[a]Department of Exercise and Health, Paderborn University, Paderborn, Germany; [b]Department of Psychology, University of Würzburg, Würzburg, Germany

ABSTRACT

The present study was conducted to disentangle the relative impact of visual and motor experience on the processing of the head fake in basketball. In a pre-test-intervention-post-test study, we investigated if the head-fake effect can be reduced with either a one-week visual-training intervention (visual-training group: *N* = 17, 10 females, 7 males, mean age = 21.2 years) or with a one-week motor-training intervention (motor-training group: *N* = 17, 10 females, 7 males, mean age = 20.9 years). Additionally, a waiting-control group (*N* = 17, 8 females, 9 males, mean age = 23.1 years) without any intervention and a group of experienced basketball players (*N* = 21, 9 females, 12 males, mean age = 23.9) was tested in the pre-post-test design (i.e., without intervention). The size of the head-fake effect was measured in a laboratory setting with a reaction time experiment, in which participants had to classify the pass direction of a faking or non-faking basketball player, who was shown in a video on a screen wall. The study revealed that the head-fake effect decreased after the training interventions. Surprisingly, the waiting-control group showed similar improvements. Thus, the reduced head-fake effect appears to be based on test-repetition effects. Moreover, after a single test session the head-fake effect approached a level that experts displayed from the outset. Even a small amount of practice (i.e., test-repetition) is sufficient to reduce, though not to abolish, the head-fake effect. We discuss this finding with regard to the common-coding approach and working memory capacity.

ARTICLE HISTORY
Received 5 May 2020
Accepted 17 November 2020

KEYWORDS
Deceptive action; deliberate practice; training intervention; test-repetition effect; attention

Introduction

Deceptive actions are used frequently in all interactive sports to gain an advantage over the opponent. Considering the practical relevance of faking and the growing body of research on this topic in sport psychology (Güldenpenning et al., 2017; Jackson & Cañal-Bruland, 2019; Loffing & Cañal-Bruland, 2017), the role of sport-specific expertise for the processing of deceptive actions is of special interest. In accordance with everyone's naïve observations, previous studies in different sports show that even professional athletes fall for fakes, although they seem to be less affected by the deception than novices (e.g., Brault et al., 2012; Henry et al., 2012; Mori & Shimada, 2013; Smeeton & Williams,

CONTACT Iris Güldenpenning iris.gueldenpenning@uni-paderborn.de Department of Exercise & Health, Paderborn University, Warburger Str. 100, 33098, Paderborn, Germany

2012). This ability to attenuate the negative impact of deceptive actions of others might be based on two different factors. First, experts typically have extensive *motor* experience of producing such fake actions themselves (e.g., Bishop et al., 2013; Wright et al., 2013). Second, experts experience such fake actions as observers. They thus have extensive *visual* experience (e.g., Cañal-Bruland & Schmidt, 2009). The main focus of this article is to evaluate the relative contributions of motor training and visual training on the perception of fake actions in sports. This research question is investigated exemplarily for the head fake in basketball, where a player orients head and gaze in one direction, but passes the ball into the other direction (e.g., Kunde et al., 2011).

The *common-coding theory* (Hommel et al., 2001; Prinz, 1997) provides an explanation for the impact of motor experience on action recognition. It proposes that the perception and the production of actions share common representations and thus, are intrinsically linked by their common codes. This bidirectional link causes *perceptual resonance*, that is, observing an action reactivates those representations that are also used to generate a corresponding action. The fine-tuning of such representations in the course of motor expertise thus improves the perceptual processing of similar actions of others (Schütz-Bosbach & Prinz, 2007). In other words, expert athletes, who rely on motor representations of higher quality, possess higher skills to discriminate (and predict) corresponding motor actions (and their outcomes) of others (Aglioti et al., 2008; Calvo-Merino et al., 2006; Casile & Giese, 2006). This suggestion has been termed *motor experience hypothesis* in the recent literature (Chen et al., 2017). The neural basis for the perceptual resonance phenomenon is the so-called action observation network (AON; Grafton, 2009). The AON consists of different brain areas, including inferior frontal gyrus, dorsal and ventral premotor cortex, and inferior and superior parietal lobule (Zentgraf et al., 2011). Two fMRI studies show that the AON is activated during the observation of deceptive actions and that this activity is strengthened by motor expertise (Bishop et al., 2013; Wright et al., 2013). Thus, motor representations are essential for the prediction of deceptive movements and can explain the perceptual superiority in experts.

Regarding the impact of visual experience for action prediction, it is argued that the recognition and pick-up of action-relevant information becomes more efficient through perceptual experience (Williams et al., 2011). Specifically, visual experience results in optimised attention allocation and cue utilisation and, consequently, enables expert athletes to extract more task-relevant information than non-experts (Huys et al., 2009; Mann et al., 2007; Williams et al., 2011). This assumption refers to the *perceptual experience hypothesis* in the current literature (Chen et al., 2017). For example, Alsharji and Wade (2016) demonstrated that seven perceptual training sessions (20 min each) increased the prediction accuracy for video scenes depicting deceptive and normal penalty throws in national youth and elite team-handball goalkeepers. Also, Ryu et al. (2018) showed that four training sessions (30 min each) were sufficient to improve anticipation performance for the landing area of the shuttle in badminton players. Anticipation performance increased both for deceptive and non-deceptive shots and for three different intervention groups (i.e., with occluded video scenes of normal, low, and high spatial-frequency information). In contrast, Güldenpenning et al. (2013) did not find improved recognition capability for the smash and the poke shot in beach-volleyball after two video-based visual training sessions (25 min each). Presumably, the difference of the visual training (i.e., video based) and the test session (i.e., based on static pictures) and the rather limited amount of visual training (50 min in total) might explain the lack of the effect of visual training in the study of Güldenpenning et al. (2013).

Generally, both motor and visual experience can contribute to fake perception in the same manner, as has already been shown for actions without any deceptive intent (e.g., Abernethy & Zawi, 2007; Abernethy et al., 2008; Urgesi et al., 2012). However, as expert athletes possess both motor expertise and visual expertise, the dissociation of the impact of motor experience and visual experience for fake perception is not trivial. One can, for example, test specific groups of participants, which predominantly have visual experience, but no or only little motor experience, for specific movements (e.g., coaches and sports journalists, who were asked to predict the success of free throws at a basket; Aglioti et al., 2008; team-handball goalkeepers, when it comes to discriminate fake throws from actual throws; Cañal-Bruland & Schmidt, 2009). Also, one can manipulate the viewing perspective of the to-be-recognized movement (i.e., front view vs. side view), as the impact of motor expertise is suggested to be viewpoint independent, whereas visual expertise strongly depends on the viewpoint (Cañal-Bruland et al., 2010; Sebanz & Shiffrar, 2009). However, until now, these manipulations were not sufficient to answer the question of how much of the expert athletes' perceptual superiority in fake perception can be explained by visual experience, motor experience, or a combination of both. Therefore, it seems warranted to investigate visual training effects and motor training effects separately, in order to evaluate their relative impact on fake perception, respectively. Such elaborate studies, to our knowledge, have only been conducted for anticipation tasks of non-fake actions (e.g., Brenton et al., 2019; Chen et al., 2017; Mulligan & Hodges, 2014). Therefore, a pre-test-intervention-post-test study was conducted for a prominent fake action in sports, namely for the head fake in basketball (e.g., Kunde et al., 2011). The results of this intervention study were compared with a group of skilled basketball players and a waiting-control group.

As mentioned above, the head fake is a deceptive action used in basketball, where a player orients head and gaze in one direction, but passes the ball into the other direction. Differences in reaction times between responses to direct passes and to head fakes signify the *head-fake effect* (Kunde et al., 2011). It arises from processing the task-relevant pass direction and task-irrelevant, interfering information, which could either be gaze direction, head orientation, or both. A recent study shows that the head-fake effect is based on the automatic processing of the head orientation, but not on the (otherwise socially important) gaze information (Weigelt et al., 2020)2020). Further studies provide evidence for the robustness of the head-fake effect for a variety of experimental manipulations, for example, for different stimulus material (i.e., photographs and video sequences; Alhaj Ahmad Alaboud et al., 2016), for different response modes (i.e., simple button presses vs. whole body movements; Alhaj Ahmad Alaboud et al., 2016), for different proportions of fake trials (i.e., 25%, 50%, and 75%; Alhaj Ahmad Alaboud et al., 2012; Güldenpenning et al., 2018), and for different avoidance instructions (i.e., ignore gaze direction and ignore head orientation; Güldenpenning et al., 2019).

Two previous studies on the head-fake effect in basketball are related to aspects of visual and motor experience. First, Weigelt et al. (2017) observed that domain-specific expertise changed the processing of the head fake in such a way that the head-fake effect was absent in basketball experts, but not in soccer experts and "true" non-athletes, when a head fake was repeated from one trial to the next trial. Specifically, when calculating the size of the head-fake effect for all trials which followed a previous fake trial, there was no head-fake effect in basketball experts. However, when calculating the size of the head-fake effect for all trials which followed a previous non-fake trial, there was a head-fake effect in basketball players. Such a pattern is termed *congruency sequence effect* (CSE; Gratton et al., 1992) in the literature on cognitive interference tasks. It points out that basketball experts were able to give irrelevant information (i.e., head orientation) higher processing weights, when this information had turned out to be helpful before (i.e., after non-fake trials), and reduce processing weight, when the same information had turned out to be detrimental (i.e., after fake trials). Thus, basketball experts have developed a certain degree of control over the processing of irrelevant information. Soccer experts and "true" non athletes, in contrast, had a head-fake effect of equal size, both after a previous fake-trial and after a previous non-fake trial and did not show specific cognitive control mechanisms. Second, the study of Güldenpenning, Schütz, et al. (2020) shows that extensive practice in responding to head fakes (i.e., more than 2000 trials performed on five successive days) decreases the head-fake effect by 18%. The results of both studies imply that participants can gain some control over the processing of the task-irrelevant head orientation, namely either specifically after a previous fake trial (Weigelt et al., 2017), or independent of the previous trial after a greater amount of practice (Güldenpenning, Schütz, et al., 2020). Thus, the question is if visual and/or motor training generally increases the control over the processing of task-irrelevant head orientation, which should reduce the head-fake effect, or if visual training and/or motor training fosters these control processes specifically after head fakes, which should result in a more expressed CSE.

The present study

An intervention study was conducted with one group of participants *performing* passes with and without head fakes (actors) and another group of participants *observing* another person performing passes with and without head fakes (observers). Thereby, each participant of the actors' group was the research twin of a participant in the observers' group. All research twins practiced (physical practice vs. observation) in one week of daily sessions. Before and after the intervention (factor *test day*: test day 1, test day 2), the size of the head-fake effect (factor *fake in trial n*: direct pass, head fake) and the size of the head-fake effect in dependence of the previous trial (factor *fake in trial n minus 1*: direct pass, head fake), was measured in a laboratory setting with a reaction time experiment, in which participants had to respond to the pass direction of a faking or non-faking basketball player, who was shown in a video on a screen wall. Responses were body movements to a left/right response buzzer and imitated the movement as if to intercept the pass. Reaction times (RT) and movement times (MT) were analysed as dependent variables. Also, a group of novices without an intervention was tested as a waiting-control group, in order to rule out that potential performance increases in the intervention groups do not simply reflect test-repetition effects. In addition, a group of basketball players was tested to further examine the role of domain-specific expertise on head-fake perception (factor *group*: motor-training group, visual-training group, waiting-control group, basketball players). The following hypotheses regarding the head-fake effect were derived: (1) If *only* visual training *or* motor training improves action perception, there should be a decrease of the head-fake effect in the corresponding group (e.g., observers), but not in the other intervention group (e.g., actors) and not in the waiting-control group. In this case, basketball players with large amounts of visual and motor experience would show similar performance as the successful training group (e.g., observers) and outperform the other intervention group (e.g., actors) and the waiting-control group. (2) If *both* visual training *and* motor training *alone* improves action perception, there should be a decrease of the head-fake effect in the observers and in the actors, but not in the waiting-control group. Basketball athletes would only outperform the waiting-control group, but neither of the intervention group. (3) If *combined* perceptual-motor skills decrease the susceptibility to head fakes, this should be reflected in a smaller head-fake effect for basketball players, as compared to the two intervention groups and the waiting-control group. (4) If domain-specific expertise strengthens the control over the task-irrelevant head orientation whenever the head fake is being repeated (Weigelt et al., 2017), this should be reflected in a *congruency sequence effect* (CSE; Gratton et al., 1992) in the basketball players, but not (or at least not to the same extent) in the two intervention groups and the waiting-control group.

Methods

Participants

Planning of the sample size was carried out using G.Power 3.1.9.2 (Faul et al., 2007). Most relevant for the present study were the interactions of the between-subjects factor *group* and the within-subjects factors *type of pass* and *test day*. For an interaction-effect between *group* and one of the within-subjects factors of $f = 0.25$, a correlation between measures of 0.4, and an α-value of .05, a sample of at least 60 participants (15 for each group) would be required to reach a power of .80.

In total, we recruited seventy-eight participants, of which fifty-six participants had no specific basketball expertise (i.e., novices), meaning that they never played in a club, and do not play at a recreational level. All novice participants reported that they don not watch basketball games or other basketball videos. Twenty-two participants were skilled basketball players. Thirty-eight of the novice participants were randomly assigned to either the motor training group (actors) or the visual training group (observers). Importantly, one actor and one observer were always coupled as research twins throughout the intervention sessions (i.e., motor training vs. visual training). The research twins were of the same sex (i.e., both male, or both female). Also, eighteen novice participants acted as a waiting-control group and only performed on the test days, but not in the intervention sessions.

Test data from 2 actors was excluded from data analyses as they performed more than 15% invalid trials (almost all invalid trials occurred as participants did not behave as instructed, i.e., they did not lift both hands from the start buttons when they performed a response, see below). The data from the corresponding research twin (two observers) was also excluded. In the waiting-control group, one participant did not show up for the second test day and was therefore excluded. In the end, data from fifty-one novice participants were analysed for the following final samples: The motor-training group consisted of 17 participants (10 females, 7 males, mean age = 20.9 years, $SD = 2.7$, 2 left-handed). The visual-training group consisted of 17 participants (10 females, 7 males, mean age = 21.2 years, *SD* = 2.4, 2 left-handed). The waiting-control group consisted of 17 participants (8 females, 9 males, mean age = 23.1 years, *SD* = 3.3).

In the group of the experienced basketball players, data of one participant was excluded due to more than 15% invalid trials (see above). Thus, the group of basketball players consisted of 21 participants (9 females, 12 males, mean age = 23.9 years, *SD* = 2.2). Regarding the basketball player's expertise, the inclusion criteria into the group of basketball players were that these athletes have a minimum of six years playing experience and were currently practicing their sport at a competitive level (mean playing experience = 12.7 years, *SD* = 3.3). Five players were active in the first and second German national league, 15 players were active in higher German regional leagues and 1 player was active in a lower German regional league.

Ethics Statement. All participants volunteered and provided written informed consent. All rights of the participants were protected, and all experiments were carried out according to the sixth revision (Seoul) of the 1964 Declaration of Helsinki by the World Medical Association (WMA). This research was also reviewed and classified as ethically noncritical by the Ethics Committee of Paderborn University. Moreover, written forms informed the participants that their data would be anonymously saved, analysed, and published. Accordingly, the present article does not include any potentially identifying information to which participants did not consent.

Apparatus and stimuli

Video sequences of a basketball player wearing a black shirt and black shorts were used as stimulus material. The recorded basketball player played in the first regional league in North Rhine-Westphalia and has had a regular schedule of 3–4 basketball-specific training sessions per week at the time of the video shooting. His playing experience was 18 years. An example of the video sequences used in the present study is provided in Figure 1. During video recording, the basketball player stood in front of a grey wall. The distance

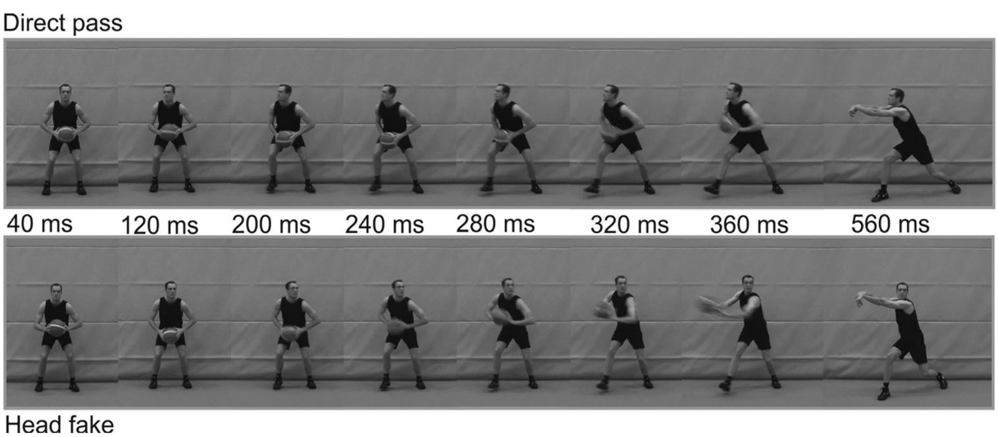

Figure 1. Example of the stimulus material used in the experiment. The video sequences of a direct pass to the left side (upper line) and a pass to the left side whilst performing a head fake (lower line) are depicted here as series of "frozen" picture frames of that sequence.

between the player and the wall was approx. 80cm. Before each trial, the basketball player held the ball in his hands, centred the ball in front of the body, and looked straight into the camera (starting position). The basketball player was recorded while passing the ball to the left or to the right side, while simultaneously gazing into the same direction (i.e., pass direction and gaze direction are congruent and reflect a direct pass) or into the opposite direction (i.e., pass direction and gaze direction are incongruent and reflect a head-fake). After video-recording, video-sequences of direct passes and head-fakes with comparable spatial–temporal parameters were chosen for the experiment. That is, the duration from the initiation of the throw (initial left/right movement of the ball) to the end of the throw (ball leaves the hands) was identical for direct passes and for head fakes. More specifically, the video sequences of both conditions started with the basketball player standing still in the starting position for 80 ms. The movement started after 120 ms for both direct passes and head fakes, when the basketball player initiated the head rotation. After 160 ms, the basketball player starts shifting his body mass into the pass direction. The movement with the whole body into the pass direction lasted from 200 ms to 360 ms. The ball left the hands after 400 ms. The arms were fully stretched after 560 ms. After 720 ms, the video was finished. One video-sequence of a direct pass to the left side, a direct pass to the right side, a head fake to the left side, and a head fake to the right side was chosen as stimulus material. These four video sequences were mirrored along the vertical axis and completed the set of stimuli. Accordingly, eight different videos, that is, four videos with direct passes to the left/right side and four videos with head fakes to the left/right side, were used for the experiment. These videos were repeatedly presented during the experimental session (see below).

Stimuli were presented with a short-distance beamer (Optoma X320 UST) on a wall of the laboratory. The size of the presented video was 250 cm × 190 cm. The presentation of the stimulus material was controlled with an IBM-compatible personal computer and the software Presentation (Version 14.5; http://www.neurobs.com).

Figure 2. Set-up of the experiment. A participant places both hands on the start buttons, which are placed at the table. The trial immediately starts with the presentation of the fixation cross (left picture). When the video sequence starts, participants have to react as fast and as accurately as possible and press the response buzzer, which corresponds with the pass direction of the presented basketball player (right picture).

A custom-build apparatus was constructed to provide a realistic response behaviour (cf. Figure 2). This apparatus consisted of two steel holdings with a distance of 170–220 cm (adapted to participants body size: wingspan + 20 cm), onto which two buzzers were mounted. Responses to the video sequences had to be given by leaning to the left/right side, in order to slap against the left/right buzzer (response buzzer), as if to intercept the observed pass. Between this apparatus, two additional buttons were placed on a small table with a height of 100 cm. These buttons (start buttons) were held down by participants with the left/right hand at the beginning of each trial and controlled the onset of the stimulus video. Time measurements started with video onset. Participants released the buttons, when they initiated their response to the left/right buzzer. Releasing one of the buttons triggered a signal, which represented the end of the reaction time and the beginning of the movement time. Slapping the buzzer signals the end of the movement.

Procedure and design

For each participant, the study started in the laboratory on test day 1. All participants signed informed consent forms and filled out a short questionnaire regarding demographic data and sport specific activities. Afterwards, participants were informed that the study starts with a reaction time experiment and received written instructions about its procedure. That is, participants were instructed to react as fast and as accurately as possible to the passing direction of a presented basketball player by either performing a button press at the left side or at the right side. Participants were also instructed to ignore the gaze direction.

Participants were placed in front of the projection wall with a distance of 160 cm. Each trial started with the instruction presented on the wall to put both hands on the start buttons. After pressing the start buttons, a fixation cross appeared and remained on the screen for 500 ms, followed by the onset of a video scene. Participants reacted to the pass direction by releasing the start buttons and by moving to the corresponding response buzzer. After pressing the response buzzer, the instruction to place the hands on the start button appeared again and the next trial started. Participants performed 16 practice trials, which were not analysed, and 120 experimental trials. The whole session in the laboratory lasted about 20 min. The four possible stimulus conditions (direct pass to the right/left side, pass with head-fake to the left/right side) occurred equally often and were randomly presented. The order of stimuli changed between participants and between pre- and post-test. This laboratory session was repeated for each group after a period of 9–10 days on test day 2.

Between the two test days, the control group and the group of basketball players did not receive any intervention.[1] However, the research twins of the two training groups (i.e., actor and observer) received an intervention training in the gymnasium on 5 consecutive days (i.e., from Monday to Friday). At each day of training, the actor was asked to perform 144 passes to the left/right side with and without a head fake. For this purpose, two small goals with a size of 150 cm × 100 cm were mounted onto gymnastic boxes, in order to allow the actor to play the pass into the goal at chest-height (Figure 3). The kind of pass (direct pass vs. head fake) that the actor was required to perform was quasi-randomly presented on the screen of a notebook. The task of the observer, who stood in front of the actor with a distance of 2 m, was to closely observe the performance of the actor. This way (i.e., involving the research

Figure 3. Set-up of the training session. In this example, the actor passes the ball into the goal, while the observer watches him doing so. In front of the actor, the kind of pass to-be-performed by the actor is being displayed on the screen of a Laptop, in a way that only the actor could see the upcoming action.

twin in the training sessions), it was assured that both actor and observer gain the same amount of experience on the basketball passes throughout all training sessions.

Data analysis

Reaction times (RTs) and movement times (MTs) were analysed as dependent variables. The time from video onset until releasing the hands from the start buttons was defined as reaction time. The period from leaving the start button until pressing the corresponding response buzzer was defined as movement time. RTs and MTs were analysed with regard to the within-subjects factors *fake in trial n minus 1* (direct pass, head fake), *fake in trial n* (direct pass vs. head fake), and *test day* (test day 1 vs. test day 2) and the between-subjects factor *group* (motor-training group, visual-training group, waiting-control group, basketball players). According to the factors of the experiment, a 2×2 x 2×4 mixed ANOVA was conducted. For the following multiple comparisons, the α-value was adapted according to Holm–Bonferroni and corrected *p*-values were provided (Hemmerich, 2016). The effect size of *t*-tests was calculated according to Cohens' d.

Additionally, we computed the coefficient of variation for RTs (CV_{RT}) and MTs (CV_{MT}) by dividing individual *SD* by individual *M*, multiplied by 100: $CV_{RT} = (SD_{RT}/M_{RT}) \times 100$; $CV_{MT} = (SD_{MT}/M_{MT}) \times 100$ (Flehmig et al., 2007). The *CV* reflects the variability of participants' responses relative to their overall level of work speed. Effects of learning might not only be evident in faster RTs and MTs, but also in a stabilising effect on performance, and thus, in a decreased *CV*. The *CV* was analysed with regard to the within-subjects factors *fake in trial n* (direct pass vs. head fake), and *test day* (test day 1 vs. test day 2), and the between-subjects factor *group* (motor-training group, visual-training group, waiting-control group, basketball players). Accordingly, a 2×2 x 4 mixed ANOVA was conducted.

Before computing the mean head-fake effect for each condition, responses were analysed for incorrect responses (0.1%), performance errors (2.0%), and for outliers (2.8%). A response was incorrect if participants pressed the wrong response button. A performance error occurred if participants did not remove both hands from the start buttons. RTs below 100 ms and above 1000 ms were classified as outliers, as well as MTs below 100 ms and above 800 ms (an SD-based outlier rejection has been shown to result in identical statistical effects; cf. Güldenpenning, Kunde, et al., 2020). In total, 3.7% of the data was excluded from further analyses (excluded data is less than the sum of incorrect responses, performance errors, and outliers, as most performance errors were also outliers).

Results

Mean reaction time analysis

Mean RTs depending on the factors *fake in trial n minus 1*, *fake in trial n, test day*, and *group* are illustrated in Figure 4. There was a main effect for the factor *fake in trial n* [$F(1, 68) = 1740.55$, $p = .000$; $\eta_p^2 = .96$], as participants reacted faster to direct passes ($M = 483.58$ ms, $SD = 37.16$ ms) than to head fakes ($M = 533.53$ ms, $SD = 37.39$ ms). The factor *fake in trial n* interacted with *fake in trial n minus 1,* [$F(1, 68) = 4.03$, $p = .049$; $\eta_p^2 = .06$]. However, the head-fake effect was only slightly smaller after a head fake ($M = 48.48$ ms, $SD =$ 10,97 ms) than after a direct pass ($M = 50.72$ ms, $SD = 12.38$ ms), and this difference only approached statistical significance [($t(71) = 1.96$, $p = .054$, $d = 0.19$)]. The factor *fake in trial n* also interacted with *group* [$F(1, 68) = 3.51$, $p = .020$, $\eta_p^2 = .13$], due to an effect of expertise. That is, the head-fake effect was significantly smaller for basketball players ($M = 43.50$ ms, $SD = 10.02$ ms) than for actors ($M = 51.94$ ms, $SD = 10.20$ ms) [($t(36) = 2.53$, $p = .036$, $d = 0.80$)], for observers ($M = 52.35$ ms, $SD = 11.22$ ms) [($t(36) = 2.63$, $p = .036$, $d = 0.77$)], and for the waiting-control group ($M = 51.54$ ms, $SD = 8.92$ ms) [($t(36) = 2.55$, $p = .036$, $d = 0.84$)].

The three-way interaction between *fake in trial n*, *test day, and group* was also significant [$F(1, 68) = 10.76$, $p < .001$, $\eta_p^2 = .32$]. To evaluate if the head-fake effect differs between test day 1 and test day 2 in dependence of group, paired t-tests were conducted. For the group of actors, the head-fake effect significantly decreased from test day 1 ($M = 56.85$ ms, $SD = 15.58$ ms) to test day 2 ($M = 47.04$ ms, $SD = 9.26$ ms) [$t(16) = 2.61$, $p = .038$, $d = 0.75$]. For the group of observers, the head-fake effect significantly decreased from test day 1 ($M = 57.09$ ms, $SD = 14.65$ ms) to test day 2 ($M = 47.61$ ms, $SD = 9.35$ ms) [$t(16) = 3.89$, $p = .004$, $d = 0.69$]. Also the waiting-control group improved significantly from test day 1 ($M = 56.65$ ms, $SD = 12.24$ ms) to test day 2 ($M = 46.43$ ms, $SD = 8.61$ ms) [$t(16) = 3.70$, $p = .006$, $d = 0.94$]. Regarding the group of basketball players, the head-fake effect was of equal size at test day 1 ($M = 45.18$ ms, $SD = 14.56$ ms) and test day 2 ($M = 42.82$ ms, $SD = 8.50$ ms) ($p > .1$). Thus, in all groups the head-fake effect reduced from test day 1 to test day 2, except in experts, who started already with a head-fake effect of a size that all other groups reached within just one test session.

No other main effect and no other interaction reached significance (all $p > .050$).

Coefficient of variation for reaction times

Mean CV_{RT} was higher at test day 1 ($M = 7.83$, $SD = 1.50$ ms) than on test day 2 ($M = 6.61$, $SD = 1.43$ ms) [$F(1, 68) = 43.20$, $p = .000$; $\eta_p^2 = .39$]. The factor *fake in trial n* interacted with

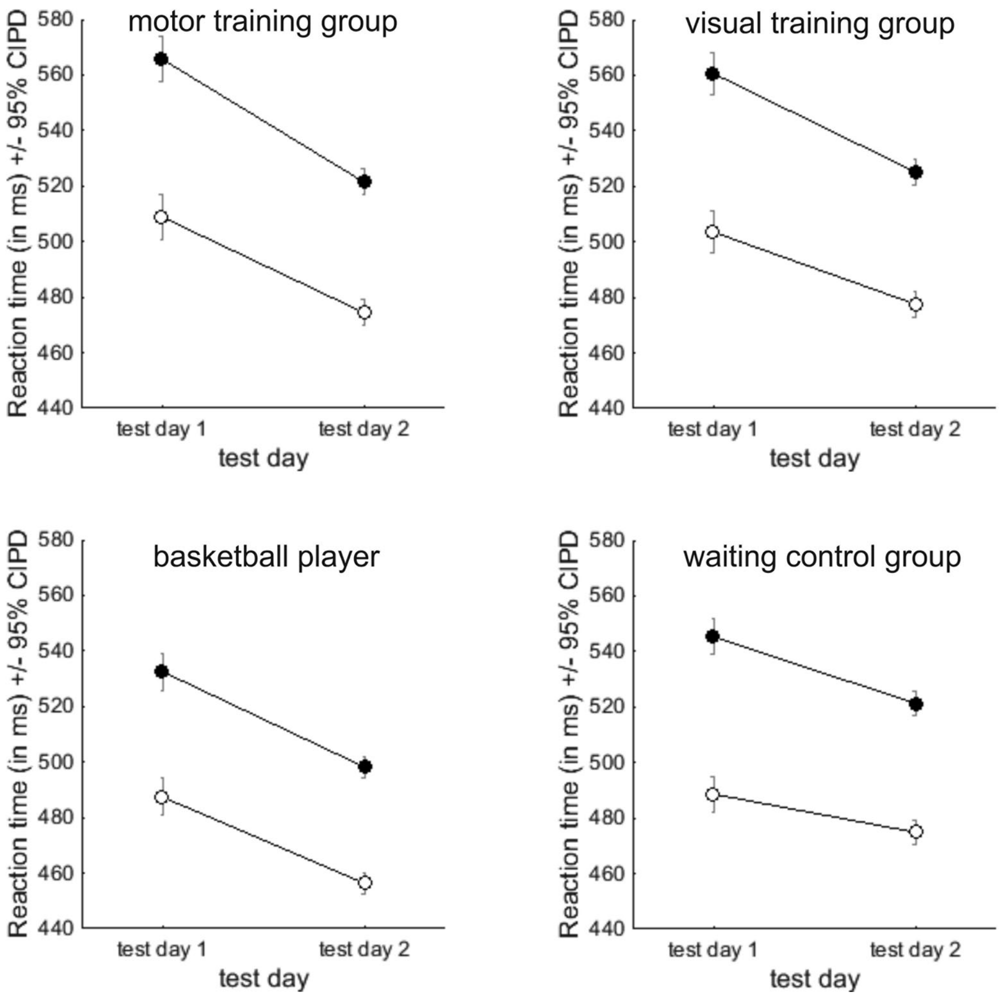

Figure 4. Reaction times to direct passes (unfilled circles) and to head fakes (filled circles) as a function of test day. Error bars represent the 95% confidence interval of the difference between direct passes and head fakes (i.e., confidence interval for paired differences = CI_{PD}; cf. Pfister & Janczyk, 2013). Two means from paired samples are significantly different if one mean is not included in the CI_{PD} around the other mean.

test day [$F(1, 68) = 13.87$, $p = .000$; $\eta_p^2 = .17$], as the decrease of the CV_{RT} from test day 1 to test day 2 was more pronounced for passes without a head fake ($M_{Diff} = 1.63$) than for passes with head-fake ($M_{Diff} = 0.82$) [($t(71) = 3.80$, $p = .000$, $d = 0.45$)]. The factor *group* also reached significance [$F(1, 68) = 3.82$, $p = .014$, $\eta_p^2 = .14$]. The RT_{CV} was descriptively higher for observers ($M = 8.01$, $SD = 1.44$) than for actors ($M = 7.18$, $SD = 1.22$), for the waiting-control group ($M = 6.61$, $SD = 0.85$), and for basketball players ($M = 7.08$, $SD = 1.31$). However, there was only a significant difference in the RT_{CV} between observers and the waiting-control group [$t(32) = 3.45$, $p = .012$, $d = 1.18$]. There was no difference between all other groups (all $ps > .10$). No other main effect and no other interaction reached significance (all $ps > .10$).

Mean movement time analyses

Mean MTs depending on the factors *fake in trial n minus 1*, *fake in trial n*, *test day*, and *group* are illustrated in Figure 5. Participants moved faster to direct passes (M = 328.65 ms, SD = 54.92 ms) than to head fakes (M = 347.20 ms, SD = 52.84 ms) [$F(1, 68) = 31.54$, $p = .000$; $\eta_p^2 = .32$]. Moreover, participants' general movement times decreased from test day 1 (M = 346.90 ms, SD = 56.90 ms) to test day 2 (M = 328.95 ms, SD = 54.92 ms) [$F(1, 68) = 13.86$, $p = .000$; $\eta_p^2 = .17$]. There was also a main effect for *group* [$F(3, 68) = 3.02$, $p = .036$, $\eta_p^2 = .12$]. Basketball players moved descriptively faster (M = 314.04 ms, SD = 54.52 ms) than actors (M = 350.47 ms, SD = 45.81 ms), observers (M = 359.66 ms, SD = 56.35 ms), and the waiting-control group (M = 327.52, SD = 48.94).

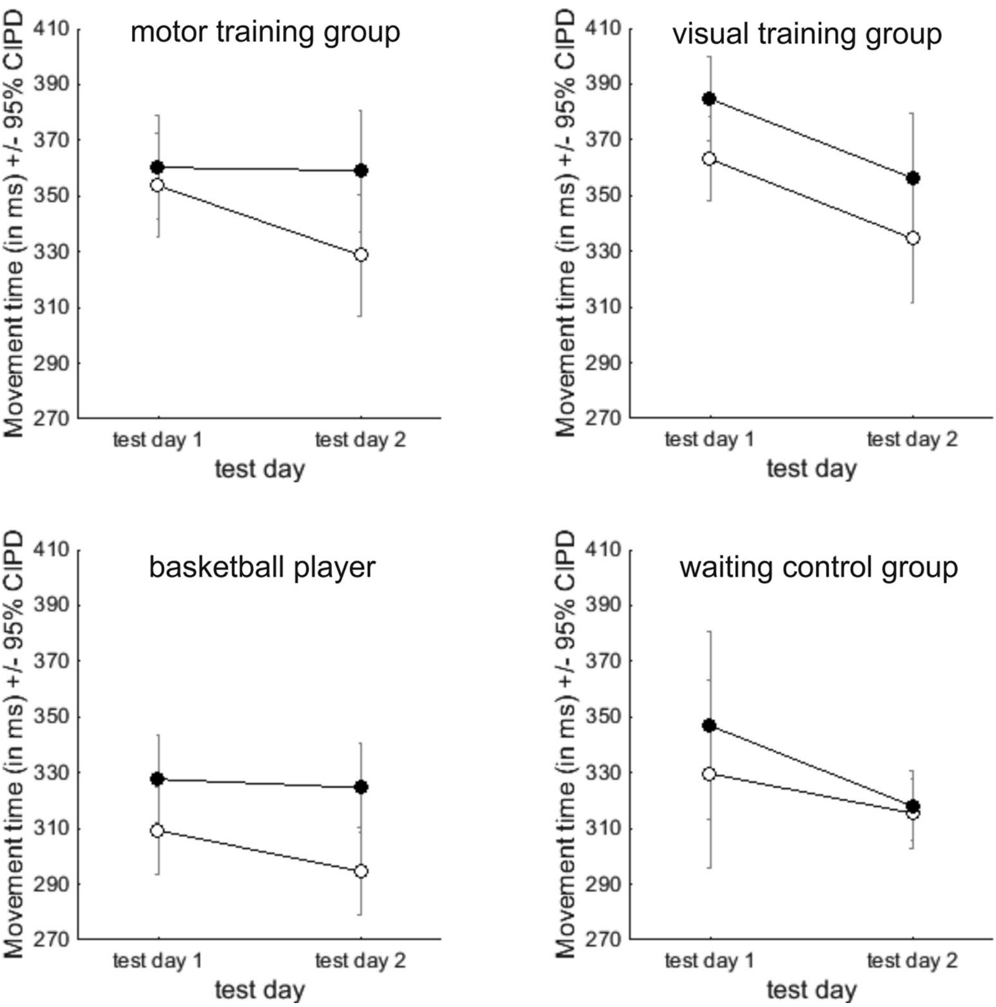

Figure 5. Movement times to direct passes (unfilled circles) and to head fakes (filled circles) as a function of test day. Error bars represent the 95% confidence interval of the difference between direct passes and head fakes (i.e., confidence interval for paired difference = CI_{PD}; Pfister & Janczyk, 2013). Two means from paired samples are significantly different if one mean is not included in the CI_{PD} around the other mean.

However, only the difference between basketball players and observers reached significance [($t(36) = 2.53$, $p = .048$, $d = 0.83$)]. The factor *trial in n minus 1* did not reach significance and also did neither of the interactions (all $p > .050$).

Coefficient of variation for movement times

Mean CV_{MT} was higher for passes with a head fake 1 ($M = 33.26$, $SD = 27.03$) than for passes without a head fake ($M = 25.35$, $SD = 24.01$) [$F(1, 68) = 6.37$, $p = .014$; $\eta_p^2 = .09$]. No other main effect and no other interaction reached significance (all $ps > .10$).

Discussion

The present study was conducted to disentangle the relative contribution of expertise, visual or motor training, and test-repetition on the size of the head-fake effect. To this end, we investigated if a one-week intervention of visual training or motor training with daily practice sessions reduces the head-fake effect. To make sure that skilled basketball players' visual and/or motor experience is indeed a factor, which reduces the head-fake effect, a group of basketball players was also tested in the experimental basketball setting. Additionally, a waiting-control group was tested to control for test-repetition effects. The main findings of the study related to the dependent variable reaction time (RT) are that the head-fake effect decreased after the training interventions, both for the visual-training and for the motor-training group. The waiting-control group showed similar improvements. Basketball players had a smaller head-fake effect than all other groups and did not show an improvement from the pre-test to the post-test. Also, the coefficient of variation in RTs decreased from test day 1 to test day 2. Regarding the dependent variable movement times (MT), the head-fake effect was also evident here, but it did not decrease from pre-test to post-test. Instead, MTs generally decreased, that is, participants moved faster to the response buzzer, independent of the type of pass (i.e., direct pass, head fake). Also, movement variability was higher for head fakes than for direct passes. The findings are consecutively discussed in detail in the following sections.

The head-fake effect in RTs as a function of previous trial type and group

The analysis of the mean RTs revealed a head-fake effect for all groups, that is, slower reaction times, when the basketball player shown in the video performed a head fake than when he performed a direct pass. The head-fake effect is argued to occur because head orientation is processed automatically during stimulus encoding and the resulting stimulus-stimulus-interference between head orientation and pass direction cannot completely be suppressed by the observer (Kunde et al., 2011). The head-fake effect found here replicates the general results of previous studies (e.g., Güldenpenning et al., 2018; Güldenpenning, Schütz, et al., 2020). Moreover, the head-fake effect was smaller for the group of basketball players than for all other groups. This finding is in accordance with previous studies on fake actions in sports (e.g., Bishop et al., 2013; Cañal-Bruland & Schmidt, 2009; Sebanz & Shiffrar, 2009; Wright et al., 2013) and with studies, which investigated anticipation performance for actions without any deceptive intent (e.g., Abernethy et al., 2008; Abernethy & Zawi, 2007; Urgesi et al., 2012). The superiority in basketball players found here might be grounded in their action representations, which improve perceptual processing of similar actions of others (i.e., common-coding theory; Schütz-Bosbach & Prinz, 2007). In other words, basketball players, who have action representations of the direct pass and the head fake available, possess higher skills to discriminate these actions than participants (i.e., actors, observers, waiting-control group) without these action representations (motor experience hypothesis; cf. Chen et al., 2017). Alternatively (or additionally), basketball players' performance might be grounded in optimised attention allocation. Specifically, basketball players' manifold visual experience might enable them to suppress the task-irrelevant information (i.e., misleading head orientation) or to spend increased attention weight to the task-relevant information (i.e., pass direction) (Kunde & Wühr, 2006), which decreased the head-fake effect relative to the other groups (perceptual experience hypothesis; Chen et al., 2017). It is fair to say that the performance difference between basketball players and the other groups, even though statistically significant, is small in general (<10 ms).

An additional finding of the study is a lack of a congruency-sequence effect (CSE; Gratton et al., 1992) in all groups. The lack of a CSE is consistent with the study of Kunde et al. (2011), but contrary to the study of Weigelt et al. (2017), who found a CSE for basketball players, but not for soccer players, and novices. Rather speculative, the different experimental setting of the study of Weigelt et al. (2017) (i.e., static pictures and simple button presses) might be responsible for the different results.

The head-fake effect in RTs as a function of test day and group

The head-fake effect declined significantly from test day 1 to test day 2 in the visual-training group, the motor-training group, and (importantly) in the waiting-control group. This pattern of results indicates that the reduced head-fake effect in the visual-training and the motor-training group is a test-repetition effect, and thus, the intervention did not have a meaningful effect. The test-repetition effect is based on participants' increased ability to attend to the pass direction and/or to ignore the gaze direction. They needed only a small amount of practice (i.e., test-repetition) to attenuate gaze direction processing and/or to strengthen pass direction processing, which decreased the head-fake effect. This sufficiency of small practice might be the result of the stimulus set, that is, we only used eight different videos of one basketball player. The test-repetition effect, thus, might reflect familiarisation with the task. Notably, in previous studies on the head-fake effect, there were no effects of practice, when analysing different experimental blocks of 50 (400 trials in total; Kunde et al., 2011), 60 (360 trials in total; Alhaj Ahmad Alaboud et al., 2016), or 100 (400 trials in total; Weigelt et al., 2017) trials. We thus conclude that the attention strategy to suppress the processing of the head orientation and/or to strengthen the processing of the pass direction needs some consolidation (McGaugh, 2000), before it can be applied by the participants. The test-repetition effect of the current study suggests that (only) a relatively small amount of practice in combination with consolidation is sufficient to improve participants' performance. This finding bears important implications from a praxis perspective when it comes to schedule training sessions. However, more research is necessary to identify the optimal amount of practice and the optimal time for consolidation. The decreased coefficient of variation in

RTs from test day 1 to test day 2 might also be an indicator of consolidation and implies that test repetition after a specific time stabilised performance between trials. This stabilisation might be the main factor for the test-repetition effects. In any case, it must be concluded from this pattern of results that visual and motor training did not decrease the head-fake effect, whereas test-repetition after a time-period of potential consolidation did.

One should consider here that deliberate practice, which the basketball players of our study have, only explains ≈ 20% of the variance in performance of sports (Macnamara et al., 2014). Additional variance can be explained by specific abilities, for example, with working memory capacity. Working memory correlates with performance in attention-demanding tasks (cf. Engle, 2002; Kane & Engle, 2002, 2003; Long & Prat, 2002). Contemporary models of working memory, which either include attention as a central component (Baddeley, 2003; Cowan et al., 2005) or even equate both constructs (Engle, 2002), explain the relation between working-memory capacity and performance in attention-demanding tasks. In this regard, a recent study showed that attention capabilities of novice participants correlate with the size of the head-fake effect (Güldenpenning et al., 2020). Working memory capacity (and other executive functions, e.g., inhibition), thus, might be a more predictive component for the head-fake effect (and for other attention-demanding situations in sports) than visual and motor practice. As there exist inconclusive findings related to this so-called cognitive component skill approach (Nougier et al., 1991; for an overview, see Voss et al., 2010), further research is necessary to investigate the correlation between cognitive and sport performance, specifically for the head-fake task. This could, for example, be done by testing participants of different skill level both in the head-fake task and in cognitive tasks (e.g., attentional capability, working memory span). However, conclusions about the causation of potential correlations between cognitive and sport performance would be difficult to draw.

The impact of cognitive functions on the perception of fake actions in sport might depend on the specific requirement of the sport situation. For the head-fake task, attention strategies, as outlined above, might be crucial to keep the head-fake effect small. However, no extraordinary anticipation skills are necessary here, as the information about the pass direction is fully available. Thus, individual differences in cognitive functioning within groups, rather than differences of visual and motor experiences between groups, might be the explanation of why the present study found only small effects of expertise. More pronounced effects of expertise have been found for a variety of perceptual anticipation tasks (e.g., Brenton et al., 2019; Chen et al., 2017; Mulligan & Hodges, 2014) and also for the recognition and discrimination of different fake actions (for an overview, see Güldenpenning et al., 2017; Jackson & Cañal-Bruland, 2019). Anticipation skills tested in these studies might be more strongly grounded in the common representations of the perception and the production of action (i.e., common-coding theory, Prinz, 1997) and, accordingly, are highly determined by motor experience.

The head-fake effect in MTs as a function of test day and group

We also found a head-fake effect for MTs. Participants thus need more time to move to the response buzzers after a pass with a head fake compared to a pass without a head fake. This finding is in accordance with previous studies on the head-fake effect in which video sequences were used and complex responses had to be performed (Alhaj Ahmad Alaboud et al., 2016; Güldenpenning, Schütz et al., 2020). It is suggested here that observing the head shift of the basketball player can lead to action induction in the observer, which results in an action tendency into the wrong direction, if a head fake is observed (cf. common-coding theory; Prinz, 1997). Therefore, participants may initially shift the centre of mass into the wrong direction, stop on the way, and correct the movement, based on online feedback processes (i.e., closed loop information processing; cf. Adams, 1971). We found such a movement pattern in a priming study with unconsciously presented prime pictures of a faking and non-faking basketball player. When participants were asked to respond to the pass direction shown at the target picture, participants initially shifted their centre of mass into the wrong direction when the gaze direction shown in the prime picture was incongruent to the pass direction depicted in the target picture. After this erroneous shift, participants changed movement direction to the correct side (Schütz, Güldenpenning, Koester, and Schack, 2020)2020.

Such a process of movement correction might be more pronounced if participants move relatively early (i.e., for fast RTs) than when they move relatively late (i.e., for slow RTs). Movement times to head fakes can thus be expected to be more variable, which is indeed reflected in the higher coefficient of variation for head fakes than for direct passes. Also, MTs of all groups decreased from test day 1 to test day 2, which points to a familiarisation with the experimental set-up, that is, with the movement which had to be performed in response to the stimuli. Moreover, basketball players moved faster than the other groups. This is not surprising, as the response movements in the experiment were similar to the movements a basketball player performs during training and competition.

Limitations of the study

The lack of an intervention effect can always be the result of an insufficient intervention, for example, of too few training sessions, of training sessions that are too short, or of training sessions with inappropriate content. In the present study, we tried to create a training scenario in which participants experienced massed practice of direct passes and with head fakes and we scheduled the training sessions to five successive days, to not overchallenge our voluntary participants. We thus tried to create an efficient, but also economic study. Previous studies have shown that a comparable amount of training (Abernethy et al., 2012; Alsharji & Wade, 2016; Ryu et al., 2018) or even less training (Hagemann & Memmert, 2006) is sufficient to improve action anticipation. However, our study differs from previous studies, as we did not guide participants' attention during training sessions to a specific area (e.g., the ball), or to specific kinematic patterns (e.g., axis of the shoulder). It might be that specifically instructing the observers and actors during the training sessions would have increased his/her performances. Also, participants might perform better in the head-fake task if the training sessions include the intention on the side of the actor (attacking situation) to really fake the observer, and the intention on the side of the observer (defending situation) to really intercept the pass of the actor. These intentions could be fostered with financial reward. Note, however, that novices reached a size of the fake effect that experts expressed straightaway. Thus, rather than assuming insufficiency of the training protocol, it seems more likely that the small amount of practice in a single test session in combination with a phase of consolidation is already effective to reduce the head fake effect, while additional visual/motor training adds only little as compared with repeated testingResults might differ if a larger set of stimuli would be used (i.e., video scene of different basketball players), as test-repetition effects based on familiarisation with the stimuli could not occur. It thus would be a challenging task for future studies to approach a more realistic situation for the laboratory test with regard to the stimulus material.

Conclusions

Action anticipation in sports is thought to be bound to domain-specific expertise. Experts are able to pick up action-relevant information earlier and more reliably than novices (Williams & Ward, 2007). This should also be true for the recognition of deceptive actions. In fact, it has been demonstrated that expert athletes are better in fake action detection than novices (for an overview, see Güldenpenning et al., 2017). Why expert athletes are superior to non-experts is under debate. One reason may be their extensive motor experience of thousands of hours of training. Another reason may be their visual experience, as they frequently observe other athletes performing fakes (Cañal-Bruland & Schmidt, 2009), or a combination of both. In the present study, visual and motor training did not decrease the head-fake effect, whereas test-repetition in combination with a phase of consolidation did. Thus, neither visual nor motor training increased the ability to attend to relevant information (i.e., pass direction) and to ignore irrelevant information (i.e., head orientation). However, a brief familiarisation with head fakes (i.e., test-repetition) suffices to remove at least some of the initial problems that novices have when responding to other peoples' head fake actions. Even though basketball players have gained much more visual and motor experience with head fakes than the group of actors and observers, they only marginally outperformed the other groups and were also significantly affected by the head fakes displayed. This is probably the very reasons for why such fake actions are so prominent in competitive high-level sports.

Note

1. Even though we tested the basketball players during the off-season, most of them took part in training and competition during the 9–10 day-period.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by Deutsche Forschungsgemeinschaft (DFG) [grant number: GU 1683/1-1 and KU 1964/13-1].

ORCID

Iris Güldenpenning http://orcid.org/0000-0003-0549-5543

References

Abernethy, B., Schorer, J., Jackson, R. C., & Hagemann, N. (2012). Perceptual training methods compared: The relative efficacy of different approaches to enhancing sport-specific anticipation. *Journal of Experimental Psychology: Applied*, *18*(2), 143–153. https://doi.org/10.1037/a0028452

Abernethy, B., & Zawi, K. (2007). Pickup of essential kinematics underpins expert perception of movement patterns. *Journal of Motor Behavior*, *39*(5), 353–367. https://doi.org/10.3200/JMBR.39.5.353-368

Abernethy, B., Zawi, K., & Jackson, R. C. (2008). Expertise and attunement to kinematic constraints. *Perception*, *37*(6), 931–948. https://doi.org/10.1068/p5340

Adams, J. A. (1971). A closed-loop theory of motor learning. *Journal of Motor Behavior*, *3*(2), 111–150. https://doi.org/10.1080/00222895.1971.10734898

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. https://doi.org/10.1038/nn.2182

Alhaj Ahmad Alaboud, M., Güldenpenning, I., Steggemann-Weinrich, Y., Kunde, W., & Weigelt, M. (2016). Täuschungshandlungen im sport: Der Blicktäuschungseffekt im basketball unter quasirealistischen Bedingungen (Hauptbeiträge). *Sportwissenschaft*, *46*(3), 223–231. https://doi.org/10.1007/s12662-016-0401-8

Alhaj Ahmad Alaboud, M., Steggemann, Y., Klein-Soetebier, T., Kunde, W., & Weigelt, M. (2012). Täuschungshandlungen im Sport. Eine experimentelle Untersuchung zur Wirkung der Häufigkeitsverteilung auf die Blicktäuschung im Basketball. *Zeitschrift für Sportpsychologie*, *19*(3), 110–121. https://doi.org/10.1026/1612-5010/a000075

Alsharji, K. E., & Wade, M. G. (2016). Perceptual training effects on anticipation of direct and deceptive 7-m throws in handball. *Journal of Sports Sciences*, *34*(2), 155–162. https://doi.org/10.1080/02640414.2015.1039463

Baddeley, A. (2003). Working memory: looking back and looking forward. *Nature Reviews Neuroscience*, *4*(10), 829–839. https://doi.org/10.1038/nrn1201

Bishop, D. T., Wright, M. J., Jackson, R. C., & Abernethy, B. (2013). Neural bases for anticipation skill in soccer: An FMRI study. *Journal of Sport and Exercise Psychology*, *35*(1), 98–109. https://doi.org/10.1123/jsep.35.1.98

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), 1–13. https://doi.org/10.1371/journal.pone.0037494

Brenton, J., Müller, S., & Dempsey, A. (2019). Visual-perceptual training with acquisition of the observed motor pattern contributes to greater improvement of visual anticipation. *Journal of Experimental Psychology: Applied*, *25*(3), 333–342. https://doi.org/10.1037/xap0000208

Calvo-Merino, B., Grezes, J., Glaser, D. E., Passingham, R. E., & Haggard, P. (2006). Seeing or doing?: Influence of visual and motor familiarity in action observation. *Current Biology*, *16*(19), 1905–1910. https://doi.org/10.1016/j.cub.2006.07.065

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

Casile, A., & Giese, M. A. (2006). Nonvisual motor training influences biological motion perception. *Current Biology*, *16*(1), 69–74. https://doi.org/10.1016/j.cub.2005.10.071

Chen, Y. H., Lee, P. H., Lu, Y. W., Huang, S. K., & Yen, N. S. (2017). Contributions of perceptual and motor experience of an observed action to anticipating its result. *Journal of Experimental Psychology: Human Perception and Performance*, *43*(2), 307–316. https://doi.org/10.1037/xhp0000312

Cowan, N., Elliott, E. M., Saults, J. S., Morey, C. C., Mattox, S., Hismjatullina, A., & Conway, A. R. A. (2005). On the capacity of attention: Its estimation and its role in working memory and cognitive aptitudes. *Cognitive Psychology*, *51*(1), 42–100. https://doi.org/10.1016/j.cogpsych.2004.12.001

Engle, R. W. (2002). Working memory capacity as executive attention. *Current Directions in Psychological Science*, *11*(1), 19–23. https://doi.org/10.1111/1467-8721.00160

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/BF03193146

Flehmig, H. C., Steinborn, M., Langner, R., Scholz, A., & Westhoff, K. (2007). Assessing intraindividual variability in sustained attention: Reliability, relation to speed and accuracy, and practice effects. *Psychology Science*, *49*(2), 132–149.

Grafton, S. T. (2009). Embodied cognition and the simulation of action to understand others. *Annals of the New York Academy of Sciences*, *1156*(1), 97–117. https://doi.org/10.1111/j.1749-6632.2009.04425.x

Gratton, G., Coles, M. G. H., & Donchin, E. (1992). Optimizing the use of information: Strategic control of activation of responses. *Journal of Experimental Psychology: General*, *121*(4), 480–506. https://doi.org/10.1037/0096-3445.121.4.480

Güldenpenning, I., Alhaj Ahmad Alaboud, M., Kunde, W., & Weigelt, M. (2018). The impact of global and local context information on the processing of deceptive actions in game sports: Both higher head-fake frequencies and head-fake repetitions reduce the size of the head-fake effect in basketball. *German Journal of Exercise and Sport Research*, *48*(3), 366–375. https://doi.org/10.1007/s12662-018-0493-4

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. https://doi.org/10.3389/fpsyg.2017.00917

Güldenpenning, I., Kunde, W., & Weigelt, M. (2020). Cognitive load reduces interference by head fakes in basketball. *Acta Psychologica*, *203*, 103013. https://doi.org/10.1016/j.actpsy.2020.103013

Güldenpenning, I., Schütz, C., Weigelt, M., & Kunde, W. (2020). Is the head-fake effect in basketball robust against practice? Analyses of trial-by-trial adaptations, frequency distributions, and mixture effects to evaluate effects of practice. *Psychological Research*, *84*(3), 823–833. https://doi.org/10.1007/s00426-018-1078-4

Güldenpenning, I., Schütz, C., Weigelt, M., & Kunde, W. (2020). Is the head-fake effect in basketball robust against practice? Analyses of trial-by-trial adaptations, frequency distributions, and mixture effects to evaluate effects of practice. *Psychological Research*, *84*, 823–833. https://doi.org/10.1007/s00426-018-1078-4

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. https://doi.org/10.1007/s00221-013-3658-2

Güldenpenning, I., Weigelt, M., & Kunde, W. (2019). Processing head fakes in basketball: Are there ironic effects of instructions on the head-fake effect in basketball? *Human Movement Science*, *67*, 102499. https://doi.org/10.1016/j.humov.2019.102499

Güldenpenning, I., Weigelt, M., Memmert, D., & Klatt, S. (2020). Processing deceptive information in sports: The size of the head-fake effect in basketball depends on the attentional capability of the observer. *Psychology of Sport and Exercise, 51*, 101764. https://doi.org/10.1016/j.psychsport.2020.101764

Hagemann, N., & Memmert, D. (2006). Coaching anticipatory skill in badminton: Laboratory versus field-based perceptual training. *Journal of Human Movement Studies*, *50*(6), 381–398.

Hemmerich, W. (2016). *StatistikGuru: Rechner zur Adjustierung des α-Niveaus*. https://statistikguru.de/rechner/adjustierung-des-alphaniveaus.html

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

Hommel, B., Müsseler, J., Aschersleben, G., & Prinz, W. (2001). The theory of event coding (TEC): A framework for perception and action planning. *Behavioral and Brain Sciences*, *24*(5), 849–878. https://doi.org/10.1017/S0140525X01000103

Huys, R., Canal-Bruland, R., Hagemann, N., Beek, P. J., Smeeton, N. J., & Williams, A. M. (2009). Global information pickup underpins anticipation of tennis shot direction. *Journal of Motor Behavior*, *41*(2), 158–171. https://doi.org/10.3200/JMBR.41.2.158-171

Jackson, R. C., & Cañal-Bruland, R. (2019). Deception in sport. In A. M. Williams & R. C. Jackson (Eds.), *Anticipation and decision making in sport* (pp. 99–116). Taylor and Francis.

Kane, M. J., & Engle, R. W. (2002). The role of prefrontal cortex in working-memory capacity, executive attention, and general fluid intelligence: An individual-differences perspective. *Psychonomic Bulletin & Review*, *9*(4), 637–671. https://doi.org/10.3758/BF03196323

Kane, M. J., & Engle, R. W. (2003). Working-memory capacity and the control of attention: The contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of Experimental Psychology: General*, *132*(1), 47–70. https://doi.org/10.1037/0096-3445.132.1.47

Kunde, W., Skirde, S., & Weigelt, M. (2011). Trust my face: Cognitive factors of head fakes in sports. *Journal of Experimental Psychology: Applied*, *17*(2), 110–127. https://doi.org/10.1037/a0023756

Kunde, W., & Wühr, P. (2006). Sequential modulations of correspondence effects across spatial dimensions and tasks. *Memory & Cognition*, *34*(2), 356–367. https://doi.org/10.3758/BF03193413

Loffing, F., & Cañal-Bruland, R. (2017). Anticipation in sport. *Current Opinion in Psychology*, *16*, 6–11. https://doi.org/10.1016/j.copsyc.2017.03.008

Long, D. L., & Prat, C. S. (2002). Working memory and Stroop interference: An individual differences investigation. *Memory & Cognition*, *30*(2), 294–301. https://doi.org/10.3758/BF03195290

Macnamara, B. N., Hambrick, D. Z., & Oswald, F. L. (2014). Deliberate practice and performance in music, games, sports, education, and professions: A meta-analysis. *Psychological Science*, *25*(8), 1608–1618. https://doi.org/10.1177/0956797614535810

Mann, D., Williams, A. M., Ward, P., & Janelle, C. M. (2007). Perceptual-cognitive expertise in sport: A meta-analysis. *Journal of Sport and Exercise Psychology*, *29*(4), 457–478. https://doi.org/10.1123/jsep.29.4.457

McGaugh, J. L. (2000). Memory-a century of consolidation. *Science*, *287*(5451), 248–251. https://doi.org/10.1126/science.287.5451.248

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

Mulligan, D., & Hodges, N. J. (2014). Throwing in the dark: Improved prediction of action outcomes following motor training without vision of the action. *Psychological Research*, *78*(5), 692–704. https://doi.org/10.1007/s00426-013-0526-4

Nougier, V., Stein, J.-F., & Bonnel, A.-M. (1991). Information processing in sport and orienting of attention. *International Journal of Sport Psychology*, *22*, 307–327.

Pfister, R., & Janczyk, M. (2013). Confidence intervals for two sample means: Calculation, interpretation, and a few simple rules. *Advances in Cognitive Psychology*, *9*(2), 74–80. https://doi.org/10.5709/acp-0133-x

Prinz, W. (1997). Perception and action planning. *European Journal of Cognitive Psychology*, *9*(2), 129–154. https://doi.org/10.1080/713752551

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. https://doi.org/10.3389/fpsyg.2018.01132

Schütz-Bosbach, S., & Prinz, W. (2007). Prospective coding in event representation. *Cognitive Processing*, *8*(2), 93–102. https://doi.org/10.1007/s10339-007-0167-x

Schütz, C., Güldenpenning, I., Koester, D., & Schack, T. (2020). Social cues can impact complex behavior unconsciously. *Scientific Reports*. https://doi.org/10.1038/s41598-020-77646-2

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. https://doi.org/10.1111/j.2044-8295.2011.02092.x

Urgesi, C., Savonitto, M. M., Fabbro, F., & Aglioti, S. M. (2012). Long and short-term plastic modeling of action prediction abilities in volleyball. *Psychological Research*, *76*(4), 542–560. https://doi.org/10.1007/s00426-011-0383-y

Voss, M. W., Kramer, A. F., Basak, C., Prakash, R. S., & Roberts, B. (2010). Are expert athletes 'expert' in the cognitive laboratory? A meta-analytic review of cognition and sport expertise. *Applied Cognitive Psychology*, *24*(6), 812–826. https://doi.org/10.1002/acp.1588

Weigelt, M., Güldenpenning, I., Steggemann-Weinrich, Y., Alhaj Ahmad Alaboud, M., & Kunde, W. (2017). Control over the processing of the opponent's gaze direction in basketball experts. *Psychonomic Bulletin & Review*, *24*(3), 828–834. https://doi.org/10.3758/s13423-016-1140-4

Weigelt, M., Güldenpenning, I., & Steggemann, Y. (2020). The head-fake effect in basketball is based on the processing of head orientation, but not on gaze direction. *Psychology*, *11*(10), 1493. https://doi.org/10.4236/psych.2020.1110095

Williams, A. M., Ford, P. R., Eccles, D. W., & Ward, P. (2011). Perceptual-cognitive expertise in sport and its acquisition: Implications for applied cognitive psychology. *Applied Cognitive Psychology*, *25*(3), 432–442. https://doi.org/10.1002/acp.1710

Williams, A. M., & Ward, P. (2007). Anticipation and decision-making: Exploring new horizons. In G. Tenenbaum & R. Eklund (Eds.), *Handbook of sport psychology* (pp. 203–223). Wiley.

Wright, M. J., Bishop, D. T., Jackson, R. C., & Abernethy, B. (2013). Brain regions concerned with the identification of deceptive soccer moves by higher-skilled and lower-skilled players. *Frontiers in Human Neuroscience*, *7*, 1–15. https://doi.org/10.3389/fnhum.2013.00851

Zentgraf, K., Munzert, J., Bischoff, M., & Newman-Norlund, R. D. (2011). Simulation during observation of human actions – Theories, empirical studies, applications. *Vision Research*, *51*(8), 827–835. https://doi.org/10.1016/j.visres.2011.01.007