The influence of basketball players' tracking speed ability on sports decision performance (#114856)

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The influence of basketball players' tracking speed ability on sports decision performance

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Background : The running speed of basketball players significantly influences the complexity of game situations. This study aims to investigate the correlation between players' tracking speed abilities and their decision-making quality.
Method s : Using the expert-novice paradigm, Experiment 1 compared the tracking accuracy in multiple object tracking (MOT) tasks at speeds of 5 °/s, 10 °/s, and 15 °/s. Experiment 2 assessed decision accuracy across three speed ranges: low speed (0.67-3.98 m/s), medium speed (3.99-7.97 m/s), and high speed (7.98-12.62 m/s).
Results : In Experiment 1, at 10 °/s, the tracking accuracy of the expert group (60.42±13.98%) was significantly higher than that of the novice group (41.25±13.93%, $P<0.001$). At the other speeds, no significant differences in accuracy were observed ($Ps>0.05$). Experiment 2 showed that the decision accuracy of the expert group was significantly higher than that of the novice group across all three speed ranges ($Ps<0.001$). At a speed of 7.98-12.62 m/s, the accuracy of shooting decisions was significantly lower than that of passing and breakthrough decisions ($Ps<0.001$). However, there was no significant difference in the accuracy of other types of decisions ($Ps>0.05$). Conclusion : (1) At a speed of 10 °/s, expert players demonstrated significantly higher tracking accuracy compared to novice players, indicating a visual attention advantage in tracking speed. (2) The decision accuracy of the expert group was significantly higher than that of the novice group across all three speed ranges. Passing decisions were generally more accurate than shooting and breakthrough decisions, particularly under high-speed conditions where passing or breakthrough strategies were more appropriate.

The influence of basketball players' tracking speed ability on sports decision performance

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Abstract

Background: The running speed of basketball players significantly influences the complexity of game situations. This study aims to investigate the correlation between players' tracking speed abilities and their decision-making quality.

Methods: Using the expert-novice paradigm, Experiment 1 compared the tracking accuracy in multiple object tracking (MOT) tasks at speeds of 5 °/s, 10 °/s, and 15 °/s. Experiment 2 assessed decision accuracy across three speed ranges: low speed (0.67-3.98 m/s), medium speed (3.99-7.97 m/s), and high speed (7.98-12.62 m/s).

Results: In Experiment 1, at 10 °/s, the tracking accuracy of the expert group (60.42±13.98%) was significantly higher than that of the novice group (41.25±13.93%, *P*<0.001). At the other speeds, no significant differences in accuracy were observed (*Ps*>0.05). Experiment 2 showed that the decision accuracy of the expert group was significantly higher than that of the novice group across all three speed ranges (*Ps*<0.001). At a speed of 7.98-12.62 m/s, the accuracy of shooting decisions was significantly lower than that of passing and breakthrough decisions (*Ps*<0.001). However, there was no significant difference in the accuracy of other types of decisions (*Ps*>0.05).

Conclusion: (1) At a speed of 10 °/s, expert players demonstrated significantly higher tracking accuracy compared to novice players, indicating a visual attention advantage in tracking speed. (2) The decision accuracy of the expert group was significantly higher than that of the novice group across all three speed ranges. Passing decisions were generally more accurate than shooting and breakthrough decisions, particularly under high-speed conditions where passing or breakthrough strategies were more appropriate.

Introduction

In sports, players' decision-making abilities play a crucial role in their execution of actions in complex situations. In team sports, a player's outstanding performance is the result of a combination of correct decision-making and proficient skills (Marasso et al. 2014). Sports decision-making directly influences sports execution, particularly in high-strategy sports such as basketball, where cognitive abilities are key variables. Players must first formulate a clear action plan and then execute corresponding strategies, which is especially important in the formation of open skills such as passing and shooting. At critical moments during competition, excellent visual attention and flexible working memory processing abilities provide the foundation for accurate decision-making (Wang et al. 2018). The first step in sports decision-making is perception, where neurons transmit information to the central nervous system to facilitate decision-making (Bahdur 2015). Over 80% of brain information is obtained through visual attention (Sui et al. 2018). In team ball games, the ability of multiple object tracking (MOT) is crucial as it allows players to simultaneously monitor the dynamic positional changes of multiple teammates and opponents (Faubert & Sidebottom 2012). MOT integrates features such as selectivity, limited capacity, and subjective effort (Faubert 2013). Modern basketball games require players to quickly identify key visual information during frequent transitions between offense and defense in order to make accurate predictions and technical movements. Therefore, coaches and sports researchers increasingly emphasize improving basketball players' visual attention to enhance the accuracy of decision-making (Jin 2020).

Basketball players must interpret key information from complex visual scenes, especially in offensive situations, and make quick decisions to score. For example, players must instantly decide whether to break through, determine the timing and positioning of passes, or decide whether to shoot. When organizing tactical coordination, the ball handler needs to accurately select the passing target from multiple players on the court, demonstrating selective attention (Mao 2010). The stimulus materials used in existing decision-making research are typically presented from a third-person perspective (Li et al. 2006), with a focus on static image analysis (Liao 2013). However, a first-person perspective allows the observer to get closer to the target object, enabling clearer judgments about its physical properties and improving the accuracy of subsequent behavioral evaluations. Using a first-person perspective in video materials can significantly improve the ecological validity of experiments.

Modern basketball games require players to quickly recognize and switch between visual stimuli, and the ability to process visual information rapidly is crucial for making effective decisions. Research has shown that in multiple object tracking tasks, tracking speed can significantly reflect differences in dynamic visual attention between experts and novices, and that target tracking speed is widely recognized and applied (Pylyshyn & Annan 2006; Sungur & Boduroglu 2012). The number of players and their running speed in basketball games increase the complexity of the scene, which in turn affects players' visual attention and decision-making processes. Studies have shown that dynamic changes on the field can influence players' attention allocation and cognitive load, both of which play important roles in the decision-making process (Williams et al. 2013). Therefore, exploring the relationship between the number of players, movement speed, and decision quality is critical for understanding the impact of visual attention on decision-making. Basketball games are highly dynamic, with 10 players constantly changing direction and speed on the court. Players must quickly identify important positions and prioritize these goals to achieve optimal performance (Vickers 2007). However, there is still limited research on the impact of tracking speed and running speed on sports decision-making. Therefore, Experiment 1 compared the accuracy of expert and novice players under different speed conditions by adjusting the target speed in the MOT task; Experiment 2 explores the decision-making accuracy of both groups in different speed ranges, aiming to analyze the advantages of expert basketball players and provide a reference for subsequent research.

The hypothesis of this study is that expert players may have advantages in visual attention and motion decision-making. Within a certain range, as target speed increases, expert players' tracking accuracy and decision-making accuracy are expected to be higher than those of novice players.

Materials & Methods

Participants

The study used G*Power 3.1.9.7 software to estimate the sample size, setting the effect size to be biased by $\eta^2 = 0.03$ (Lakens 2014), $\alpha = 0.05$. The calculation indicated that a statistical test power of 0.80 could be achieved with 40 participants (20 in each group). Considering the potential for participant withdrawal during the experiment, 48 participants were ultimately selected, with 24 participants in each group (Jin 2020). The participants were divided into two groups: an expert group and a novice group, based on their basketball experience and skill level. The expert group consisted of female players from the Northeast Division of the Chinese University Basketball League First Division (Pylyshyn & Annan 2006), with an average playing time of over 15 minutes per game, a minimum sports level of Level 1 (including Level 1), an average age of (21.20 ± 2.12) years, an average training period of (9.10 ± 2.14) years, and a weekly training time of (27.64 ± 7.16) hours in the past year. The novice group included female students from the basketball elective course at Northwest Normal University, with an average age of (19.83 ± 0.89) years, an average training period of (1.60 ± 0.49) years, a weekly training time of (1.20 ± 0.15) hours, and no formal sports level. All participants were right-handed, with normal or corrected vision, and maintained stable emotions and a good mental state before the experiment. They played electronic games for no more than 4 hours per week and experienced no fatigue. The experiment was approved by the ethics committee of Northwest Normal University (No. NWNU-20230301). Prior to the experiment, participants were thoroughly informed of the purpose and procedures of the study and were required to sign an informed consent form.

Design

Experiment 1 used a multiple object tracking task to assess tracking performance at different target speeds. A mixed experimental design was employed: 2 (group: experts, novices) × 3 (target speed: 5 °/s, 10 °/s, 15 °/s), where the group was the between-subjects variable, the target speed was the within-subjects variable, and the dependent variable was tracking accuracy. The accuracy calculation was based on the proportion of correctly selected targets in each participant's trials.

Experiment 2 followed a 2 (group: experts, novices) × 2 (decision type: intuition, cognition) × 3 (attack method: passing, shooting, breakthrough) × 3 (speed: low speed 0.67-3.98 m/s, medium speed 3.99-7.97 m/s, high speed 7.98-12.62 m/s) design. The group was the between-subjects variable, the target speed was the within-subjects variable, and the dependent variable was decision accuracy. During the experiment, a principal investigator was present to accompany and ensure the smooth progression of the procedure.

Apparatus

The experiment was conducted using a Lenovo E15 laptop, with an operating system of Windows 10, a 15.6-inch display screen, a screen resolution of 1920 × 1080 pixels, and a refresh rate of 60 Hz. At the beginning of Experiment 1, a "+" symbol lasting 500 ms was displayed at the center of the screen, followed by 12 white spheres. Three of the spheres turned blue and flashed three times, marking them as target objects, while the remaining spheres remained white as non-target objects. Subsequently, all spheres turned white and moved randomly at speeds of 5 °/s, 10 °/s, and 15 °/s. After 8 seconds, the spheres stopped moving, and the target objects turned red. Participants were required to determine how many of the red spheres contained target objects, press the corresponding number keys, and proceed to the next trial.

Stimuli

The offensive video sequences used in Experiment 2 were selected from the WCBA league's forward position, consisting of 129 segments, each depicting passing, breakthrough, and shooting actions (Jin et al. 2023). Ten high-level female basketball players recreated these scenes on-site, with each team wearing black and white jerseys and identified by their numbers. A tall player with short hair wore a sports camera (model: Insta360 One X) to capture footage from the player's first-person perspective (Ping 2019).

(1) Determination of content validity: Five CUBA basketball coaches and CBA players reviewed and validated the 129 selected WCBA league offensive position attack videos, as well as the final first-person perspective videos (Spitz et al. 2018).

(2) Determination of structural validity: The study also selected 6 high-level basketball players and 6 college students enrolled in the basketball elective course for validity testing. This step aimed to eliminate the "ceiling effect" and "floor effect," ensuring that each video could effectively distinguish decision-making efficiency among players at different skill levels. For videos with low discriminative power, the video durations were adjusted by either extending or shortening the clips until each video clearly differentiated the decision-making speed and accuracy between high-level players and elective course students. As expected, high-level players demonstrated higher decision-making speed and accuracy (Dai et al. 2011), thus forming the experimental materials for this study (Wang 2010). The final video duration for each clip was 3000 ms.

Video analysis

In the statistical analysis of 60 basketball game videos from Experiment 2, it was noted that there were 10 players in 59 videos, while only one video featured 9 players. Due to this fixed number characteristic, analysis of the number of players did not provide effective insights into the results of sports decision-making. Therefore, following consultations with experts, Experiment 2 focused on analyzing the average speed of the ball handler.

Notes: ■pass, ●shoot.

Figure 1 Example of positioning calibration for ball bearers

Video analysis technology is a critical tool in modern sports science research, providing detailed data on player performance. By recording the time and location (x and y-axis coordinates) of movements during competitions, it is possible to describe the behavior of players through ordinary video footage (Kamble et al. 2019). The analysis tracks location changes over a specified time period, which are determined by the nature of the event. Based on the standard dimensions of a basketball court (28 meters in length and 15 meters in width), the court is set within a Cartesian coordinate system with an x-axis of 28 meters and a y-axis of 15 meters, with a stride value of 1 meter. Each time the step size increases by 1 meter, this serves as a reference for the grid covering the field, where mapping the event onto the grid results in corresponding x and y values (Cullinane et al. 2024). See Figure 1.

Storm player software (version 5.81) is employed to play the video material and calculate the ball handler's speed using the following steps:

The time interval is set to Δt (0.5 s), and the position changes of the ball handler are checked within each 0.5-second interval. If there is no change in the player's position, the location is recorded at 0.5-second intervals. If a change in position occurs, the location is recalibrated based on the time of the change, and the time interval is recalculated. This algorithm enables real-time detection and tracking of the ball handler's position and movement.

By recording the position changes over a continuous period, the player's running speed is calculated using the following formula. If the player moves from position P1 (x_1, y_1) to position P2 (x_2, y_2) within time Δ t, the velocity v can be expressed as: $v = \frac{P2 - P1}{\Delta t} = \frac{\sqrt{(x2 - x1)^2 + (y2 - y1)^2}}{\Delta t}$

By calculating the average speed of the ball handler in each video and combining it with the speed settings of the multiple object tracking task in Experiment 1, the decision video material was divided into three speed ranges: 0.67-3.98 m/s, 3.99-7.97 m/s, and 7.98-12.62 m/s. The results showed that, within the range of 0.67-3.98 m/s, there were a total of 28 videos (including 6 passes, 13 shots, and 9 breakthroughs). In the range of 3.99-7.97 m/s, there were a total of 27 videos (including 11 passes, 7 shots, and 9 breakthroughs). In the range of 7.98-12.62 m/s, there were only 5 videos (including 3 passes and 2 breakthroughs), with no shooting decisions made by the ball handler while running at high speed.

Procedure

Experiment 1: A multiple object tracking experimental program was developed using Matlab R2020b software. The distance between the participant and the screen was approximately 60 cm, and the stimulus presentation area covered the entire screen. To familiarize the participants with the experimental process, five practice trials were conducted before the formal experiment. The experiment consisted of 10 blocks, each containing 3 trials corresponding to the three target speeds: 5 °/s, 10 °/s, and 15 °/s, for a total of 30 trials. A 10-second white screen was displayed between each block to alleviate eye fatigue. The experimental sequence was counterbalanced within subjects. The entire experiment lasted approximately 11 minutes.

Figure 2 Basic process of sports decision-making task

Experiment 2 was programmed using Experiment Builder 2.3 software. Referring to previous research, the presentation time for intuitive decisions was set at 600 ms, while the presentation time for cognitive decisions was set at 1200 ms (Lu 2018). Intuitive decision-making task instructions: "The '+' sign is first displayed in the center of the screen, followed by a blank screen and a first-person perspective game video, prompting: 'Please make a decision.' Carefully observe and judge the attacking style of the ball handler within 0.6 seconds. The situation on the court is urgent; please make a quick decision. Press 1 for passing, press 2 for shooting, and press 3 for a breakthrough." Cognitive decision-making task instructions: "The '+' sign is first displayed in the center of the screen, followed by a blank screen and a first-person perspective game video, prompting: 'Please make a decision.' Carefully observe and judge the attacking style of the ball handler within 1.2 seconds. Please make accurate and prompt decisions. Press 1 for passing, press 2 for shooting, and press 3 for a breakthrough." After the practice trials are completed, the screen will display "Start formal experiment," and the button operation will remain consistent with the preparation stage. The video will be played in full screen, and participants will alternate between cognitive and intuitive decision-making tasks using an ABBA design to balance task order (Liu 2012), with a 30-second break between tasks. Three types of attack videos for each decision-making task will be randomly presented, and the entire experimental process will take approximately 27 minutes.

Statistical analysis

The data for Experiment 1 were recorded and collected using Matlab R2020b software, while the data for Experiment 2 were recorded and collected using Experiment Builder 2.3 software and analyzed using SPSS 29.0 software. Experiment 1 uses tracking accuracy as the dependent variable and employs a repeated measures analysis of variance (ANOVA) with 2 (groups) × 3 (target velocity). Experiment 2 uses decision accuracy as the dependent variable and employs a repeated measures ANOVA with 2 (group) × 2 (decision type) × 3 (attack style) × 3 (speed). If the interaction effect is significant, further simple effects analysis will be performed. The Bonferroni method will then be used for pairwise comparisons. P <0.05 will be used as the threshold for statistically significant differences.

Results

Tracking accuracy of experts and novice MOT at different speeds

Note

$^{**}P<0.01$

Figure 3 Tracking accuracy of MOT at different speeds for experts and novices

A repeated measures ANOVA was performed with target speed (5 °/s, 10 °/s, 15 °/s) as the within-subjects variable, group (expert group, novice group) as the between-subjects variable, and tracking accuracy as the dependent variable. The results showed that the main effect of the group was significant, with the accuracy of the expert group (56.81 ± 13.11%) being significantly higher than that of the novice group (46.95 ± 12.70%, $P < 0.001$). The main effect of target speed was significant, $F(2, 92) = 196.722$, $P < 0.001$, $\eta^2 = 0.810$. Post-hoc analysis revealed that as target speed increased, accuracy significantly decreased ($Ps < 0.01$). The interaction effect between target speed and group was also significant, $F(2, 92) = 5.891$, $P = 0.006$, $\eta^2 = 0.114$. Simple effects analysis showed that at 10 °/s, the accuracy of the expert group (60.42 ± 13.98%) was significantly higher than that of the novice group (41.25 ± 13.93%, $P < 0.001$); at other speeds, no significant differences in accuracy were found ($Ps > 0.05$). See Figure 3.

Decision accuracy of expert and novice video materials at different speeds

A repeated measures ANOVA was conducted using group (expert group, novice group) as the between-subjects variable, decision type (intuition, cognition), attack method (passing, shooting, breakthrough), and speed (low speed: 0.67-3.98 m/s, medium speed: 3.99-7.97 m/s, high speed: 7.98-12.62 m/s) as within-subjects variables, with accuracy as the dependent variable. The results are shown in Table 1.

The analysis revealed a significant main effect of group, with the decision accuracy of the expert group (0.66 ± 0.11) being significantly higher than that of the novice group (0.32 ± 0.10), $F(1, 46) = 1069.644$, $P < 0.001$, $\eta^2 = 0.959$. The main effect of decision type was also significant, with the accuracy of intuitive decisions (0.47 ± 0.11) being significantly lower than that of cognitive decisions (0.52 ± 0.10), $F(1, 46) = 45.818$, $P < 0.001$, $\eta^2 = 0.499$. The main effect of attack method was significant, $F(2, 92) = 171.733$, $P < 0.001$, $\eta^2 = 0.789$. Post-hoc analysis revealed that the accuracy of shooting decisions (0.40 ± 0.10) was significantly lower than that of passing (0.55 ± 0.11) and breakthrough (0.53 ± 0.12), $Ps < 0.001$; there was no significant difference in the accuracy of passing and breakthrough decisions ($P = 0.05$). The main effect of speed was significant, $F(2, 92) = 729.000$, $P < 0.001$, $\eta^2 = 0.941$. Post-hoc analysis showed that as speed increased, decision accuracy significantly decreased ($Ps < 0.001$).

The interaction effect between group and decision type was significant, $F(1, 46) = 7.050$, $P = 0.011$, $\eta^2 = 0.133$. The interaction effect between group and attack method was significant, $F(2, 92) = 38.394$, $P < 0.001$, $\eta^2 = 0.455$. The interaction effect between group and speed was significant, $F(2, 92) = 41.583$, $P < 0.001$, $\eta^2 = 0.475$. The interaction effect between decision type and attack method was significant, $F(2, 92) = 5.243$, $P = 0.007$, $\eta^2 = 0.102$. The interaction effect of group, decision type, and attack method was significant, $F(2, 92) = 3.923$, $P = 0.023$, $\eta^2 = 0.079$. The interaction effect between decision type and speed was significant, $F(2, 92) = 7.254$, $P = 0.001$, $\eta^2 = 0.136$. The interaction effect between attack method and speed was significant, $F(4, 184) = 177.963$, $P < 0.001$, $\eta^2 = 0.795$. The interaction effect of group, attack method, and speed was significant, $F(4, 184) = 31.753$, $P < 0.001$, $\eta^2 = 0.408$. The interaction effect of decision type, attack method, and speed was significant, $F(4, 184) = 5.054$, $P < 0.001$, $\eta^2 = 0.099$. No other significant interaction effects were found ($Ps > 0.05$).

To further explore the interaction effect between groups and decision types, a simple effects analysis was conducted, which revealed that the decision accuracy of the expert group was significantly higher than that of the novice group in both intuitive and cognitive decision-making tasks ($Ps < 0.001$). In both groups, the accuracy of cognitive decision-making was significantly higher than that of intuitive decision-making ($Ps < 0.01$).

To test the interaction effect between groups and attack methods, a simple effects analysis was conducted, showing that, across all attack methods, the decision accuracy of the expert group was significantly higher than that of the novice group ($Ps < 0.001$). In the expert group, the accuracy of shooting decisions (0.52 ± 0.10) was significantly lower than that of passing (0.74 ± 0.12) and breakthrough (0.72 ± 0.13) ($Ps < 0.001$), with no significant difference between passing and breakthrough decisions ($P = 0.139$). In the novice group, the accuracy of shooting decisions (0.27 ± 0.10) was significantly lower than that of passing (0.35 ± 0.10) and breakthrough (0.34 ± 0.11) ($Ps < 0.001$), with no significant difference between passing and breakthrough decisions ($P = 0.139$).

Table 1 Decision accuracy of experts and novices at different video speeds

In order to test the interaction effect between group and speed, a simple effects analysis was conducted, and it was found that the decision accuracy of the expert group was significantly higher than that of the novice group at all three speeds ($Ps < 0.001$). In both the expert and novice groups, as the ball handler's speed increased, decision accuracy significantly decreased ($Ps < 0.001$).

In order to test the interaction effect between decision types and attack methods, a simple effects analysis was conducted, and it was found that among the three attack methods, the accuracy of cognitive decision-making was significantly higher than that of intuitive decision-making ($Ps < 0.05$). In both intuitive and cognitive decision-making, the accuracy of shooting decisions was significantly lower than that of passing and breakthrough ($Ps < 0.001$), while there was no significant difference in the accuracy of passing and breakthrough decisions ($Ps > 0.05$).
In order to test the interaction effect between decision type and speed, a simple effects analysis was conducted, and it was found that there was no significant difference ($P = 0.108$) between intuitive decision accuracy (0.62 ± 0.09) and cognitive decision accuracy (0.65 ± 0.10) at 0.67-3.98 m/s. At speeds of 3.99-7.97 m/s and 7.98-12.62 m/s, the accuracy of cognitive decision-making was significantly higher than that of intuitive decision-making ($Ps < 0.001$). In both intuitive and cognitive decision-making, the accuracy of passing decisions was significantly higher than that of shooting and breakthrough ($Ps < 0.001$), and the accuracy of shooting decisions was significantly higher than that of breakthrough ($Ps < 0.001$).

In order to test the interaction effect between attack mode and speed, a simple effects analysis was conducted, and it was found that there was no significant difference in decision accuracy among the three attack modes at 0.67-3.98 m/s and 3.99-7.97 m/s ($Ps > 0.05$). At 7.98-12.62 m/s, the decision-making accuracy for shooting was significantly lower than that for passing and breakthrough (*Ps* < 0.001), and there was no significant difference in decision-making accuracy between passing and breakthrough (*Ps* > 0.05). Among the three offensive methods, the accuracy of passing decisions was greater than that of shooting and breakthrough (*Ps* < 0.001), and the accuracy of shooting decisions was greater than that of breakthrough (*Ps* < 0.001).

In order to test the interaction effects between groups, decision types, and attack methods, a simple effects analysis was conducted, and it was found that the expert group had significantly higher decision accuracy than the novice group in both intuitive and cognitive decision-making tasks across all three attack methods (*Ps* < 0.001). In the expert group, the accuracy of cognitive decision-making for passing and breakthrough was significantly higher than that of intuitive decision-making (*Ps* < 0.001). In the novice group, the accuracy of cognitive decision-making during passing (0.38 ± 0.11) was significantly higher than that of intuitive decision-making (0.33 ± 0.09, *P* < 0.01). There was no significant difference in the accuracy of other decisions (*Ps* > 0.05). In the expert group's intuitive decision-making, the accuracy of shooting decisions was significantly lower than that of passing and breakthrough (*Ps* < 0.001), while the accuracy of passing decisions (0.70 ± 0.11) was significantly higher than that of breakthrough decisions (0.67 ± 0.14, *P* = 0.024). In the expert group's cognitive decision-making, the accuracy of shooting decisions was significantly lower than that of passing and breakthrough (*Ps* < 0.001), while there was no significant difference in the accuracy of passing decisions (0.78 ± 0.12) and breakthrough decisions (0.77 ± 0.11) (*P* = 0.981). In both intuitive and cognitive decision-making in the novice group, the accuracy of shooting decisions was significantly lower than that of passing and breakthrough (*Ps* < 0.01), while there was no significant difference in the accuracy of passing and breakthrough decisions (*Ps* > 0.05).

In order to test the interaction effects between groups, decision type, and speed, a simple effects analysis was conducted, and it was found that in both intuitive and cognitive decision-making, the decision accuracy of the expert group was significantly higher than that of the novice group at all three video speeds (*Ps* < 0.001). In both the expert and novice groups, the accuracy of cognitive decision-making was significantly higher than that of intuitive decision-making when the ball handler's speed was between 3.99-7.97 m/s and 7.98-12.62 m/s (*Ps* < 0.05), while there was no significant difference in the accuracy of other decisions (*Ps* > 0.05). In the cognitive decision-making of the expert group, there was no significant difference in decision accuracy between 0.67-3.98 m/s (0.84 ± 0.10) and 3.99-7.97 m/s (0.80 ± 0.11) (*P* = 0.104), while the accuracy of other decisions decreased significantly with increasing speed (*Ps* < 0.01). At different speeds for the three attack methods, the decision accuracy of the expert group was significantly higher than that of the novice group (*Ps* < 0.001).

In order to test the interaction effects between groups, attack methods, and speed, a simple effects analysis was conducted, and it was found that the decision accuracy of the expert group was significantly higher than that of the novice group across different speeds for the three attack methods (*Ps* < 0.001). The accuracy of shooting decisions for both the expert and novice groups was significantly lower than that of passing and breakthrough at 7.98-12.62 m/s (*Ps* < 0.001), while there was no significant difference in the accuracy of other decisions (*Ps* > 0.05). In the expert group's shooting decision, there was no significant difference in the accuracy of decisions between 0.67-3.98 m/s (0.80 ± 0.09) and 3.99-7.97 m/s (0.76 ± 0.11) (*P* = 0.076), while the accuracy of other decisions decreased significantly with increasing speed (*Ps* < 0.05).

In order to test the interaction effects between decision types, offensive styles, and speed, a simple effects analysis was conducted, and it was found that the accuracy of cognitive decisions was significantly higher than that of intuitive decisions at 7.98–12.62 m/s for passing, 3.99-7.97 m/s for shooting, and 3.99-7.97 m/s and 7.98–12.62 m/s for breakthrough (*Ps* < 0.05), while there was no significant difference in the accuracy of other decisions (*Ps* > 0.05). At a speed of 7.98-12.62 m/s for both intuitive and cognitive decision-making, the accuracy of shooting decisions was significantly lower than that of passing and breakthrough (*Ps* < 0.001), while there was no significant difference in the accuracy of other decisions (*Ps* > 0.05). In breakthrough cognitive decision-making, there was no significant difference in decision accuracy between 0.67-3.98 m/s (0.64 ± 0.11) and 3.99-7.97 m/s (0.59 ± 0.12) (*P* = 0.067), while the accuracy of other decisions decreased significantly with increasing speed (*Ps* < 0.05).

Discussion

Experiment 1 aimed to explore the visual attention differences between expert and novice players in multiple object tracking tasks under different target speed conditions. As the target speed increased, the tracking accuracy of both groups showed a decreasing trend. However, at a target speed of 10 °/s, the accuracy of the expert group was significantly higher than that of the novice group (*P* < 0.001), reflecting the visual attention advantage of expert players in tracking speed, thereby supporting our hypothesis.

This result aligns with the findings of Jingwen Song (Song 2012), but differs from those of Jin Peng et al. on the differences in target velocity tracking accuracy, which may be attributed to gender differences among the subjects (Jin 2020). There was no significant difference in tracking accuracy between the two groups at target speeds of 5 °/s and 15 °/s. The attention resources consumed by the target speed task are limited, and the difficulty of the task increases with the target speed. Due to the lower difficulty of the 5 °/s task, players can manage it easily; the 15 °/s task, however, is too difficult and exceeds the visual capability of both groups of players. Thus, at a target speed of 10 °/s, expert players demonstrated higher accuracy based on their ability to quickly process visual information acquired through long-term training and competition. Zhang Xuemin's research also shows that players outperform control groups in tracking tasks (Zhang et al. 2005).

Experiment 2 examined the performance of expert and novice groups in motion decision-making tasks across different speed ranges and decision types. The results showed that the decision-making accuracy of the expert group was significantly higher than that of the novice group across all three speed ranges (*Ps* < 0.001), confirming the advantage of expert players in decision-making ability. As speed increased, decision accuracy significantly decreased (*Ps* < 0.001), indicating that players' decision flexibility and accuracy are affected by targets of different speeds. The faster the target movement speed, the greater the cognitive load on players, which impacts decision-making accuracy. Specifically, when the ball handler moves at high speed, the player must quickly assess the relative position of the ball handler to other players in order to respond quickly to the rapidly changing game environment. This rapid response ability is a core characteristic of high-level players, which can significantly improve their decision-making efficiency in complex environments (Mann et al. 2007).

Moreover, fast-paced basketball games may make players more inclined to rely on intuitive decision-making rather than thoughtful analysis, thereby increasing the diversity and flexibility of decision-making. Due to long-term training and competition, expert players have accumulated a wealth of knowledge, which makes their decision-making abilities significantly better than those of novice players. Wu Yin's research further suggests that long-term exercise training can alter brain structure and help players process complex visual information more efficiently during sports (Wu et al. 2015). Ericsson and Lehmann argue that long-term exercise can increase the excitability of players' nervous systems, making them more flexible in visual attention regulation (Ericsson & Lehmann 1996). Although the analysis of the number of players did not provide meaningful results, the relationship between the ball handler's movement speed and motion decisions is significant.

Previous studies have shown that as the number of players on the field increases, players' cognitive load significantly increases, affecting both decision-making time and accuracy (Vaeyens et al. 2010). In this study, the complex interaction between visual attention and motion decision-making was revealed by analyzing the performance of ball handlers under different speed conditions. Specifically, the average running speed and total running distance not only provide information on players' physical condition but also offer insights into their decision-making ability at critical moments. At high speeds, players' visual attention may be disrupted, leading to neglect of the surrounding environment, thus impacting decision-making quality. Research has shown a significant correlation between visual attention and sports decision-making. During high-speed sports, players tend to rely more on intuitive decision-making, which may lead to misjudgment. The results of this study confirmed this finding, showing that the accuracy of intuitive decision-making was significantly lower than that of cognitive decision-making ($P < 0.001$). Additionally, the ball handler did not make any shooting decisions while running at high speeds (7.98-12.62 m/s), providing important insights for practical training. This suggests that other offensive methods may be more effective than shooting in high-speed situations.

Spitz et al.'s research suggests that there is no significant difference in the accuracy of football referees when reviewing plays in slow motion compared to real-time decisions, and slowing down video speed does not improve decision accuracy, possibly due to a loss of authenticity in the real-time environment (Spitz et al. 2018). In contrast to Spitz et al.'s findings, this study supports Lorains' viewpoint. Lorains' research explains why expert players make more accurate decisions at high speeds: faster speeds better align with the dynamic, time-sensitive decision-making environment in sports, meeting the cognitive processing needs of players (Lorains et al. 2013). This is reflected in the experimental data: as speed increases, decision accuracy significantly decreases. However, the expert group still showed significant advantages over the novice group under high-speed conditions, indicating that precise allocation of visual attention plays a key role in decision-making. The fast-moving competitive environment places higher demands on players' attention allocation and timely decision-making, further emphasizing the crucial role of visual attention in sports decision-making.

This study validates the promoting effect of multiple object tracking training on sports decision-making ability, underscoring the close relationship between visual attention and sports decision-making. However, research on how multiple object tracking training affects the brain mechanisms of players is still insufficient. Future studies should integrate brain imaging technology to further explore the neural adaptive changes caused by training, providing a scientific basis for training strategies aimed at enhancing players' decision-making abilities.

Conclusions

(1) At a speed of 10 °/s, the tracking accuracy of the expert group in multiple object tracking tasks is significantly higher than that of the novice group, reflecting the visual attention advantage of expert players in tracking speed.

(2) In basketball decision-making tasks, the expert group had significantly higher decision accuracy than the novice group at all three speeds. Among the three attacking methods, the accuracy of passing decisions was significantly higher than shooting and breakthrough, especially under high-speed conditions of 7.98-12.62 m/s, where passing or breakthrough strategies were more appropriate.

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Competing Interests

The authors declare that they have no competing interests.

Author Contributions

Qi-feng Gou conceived and designed the experiments, performed the experiments, analyzed the data, prepared figures and/or tables, and approved the final draft.

Sun-nan Li conceived and designed the experiments, prepared figures and/or tables, reviewed drafts of the paper, and approved the final draft.

Human Ethics

The following information was supplied relating to ethical approvals (i.e., approving body and any reference numbers):

This work was approved by the regional ethics committee of the Northwest Normal University (No. NWNU-20230301).

Data Availability

The following information was supplied regarding data availability:

The raw measurements are available in the Supplemental Files.

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Table 1(on next page)

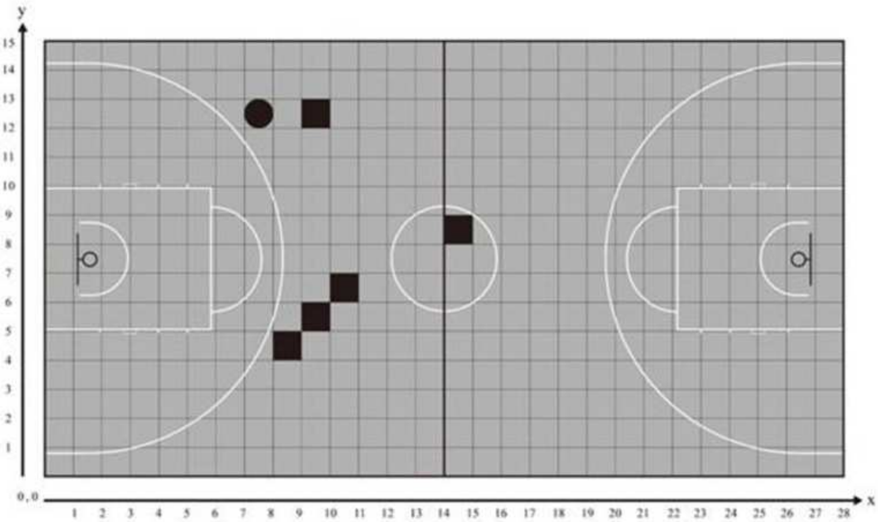
Decision accuracy of experts and novices at different video speeds

Table 1 Decision accuracy of experts and novices at different video speeds

group	type	Speed (m/s)	pass	shoot	breakthrough
			M±*SD*	*M*±*SD*	*M*±*SD*
expert	intuition	0.67-3.98	0.83±0.07	0.79±0.07	0.80±0.09
		3.99-7.97	0.78±0.11	0.75±0.08	0.72±0.13
		7.98-12.62	0.49±0.15	\	0.47±0.19
	cognition	0.67-3.98	0.86±0.10	0.82±0.10	0.85±0.11
		3.99-7.97	0.82±0.09	0.78±0.13	0.80±0.12
		7.98-12.62	0.67±0.17	\	0.67±0.13
novice	intuition	0.67-3.98	0.44±0.09	0.43±0.11	0.44±0.12
		3.99-7.97	0.35±0.10	0.35±0.08	0.35±0.11
		7.98-12.62	0.20±0.08	\	0.18±0.08
	cognition	0.67-3.98	0.47±0.10	0.45±0.10	0.44±0.11
		3.99-7.97	0.38±0.13	0.39±0.09	0.37±0.10
		7.98-12.62	0.28±0.11	\	0.24±0.11

Figure 1

Figure 1 Example of positioning calibration for ball bearers



Notes: ■pass, ●shoot.

Figure 1 Example of positioning calibration for ball bearers

Figure 2

Figure 2 Basic process of sports decision-making task

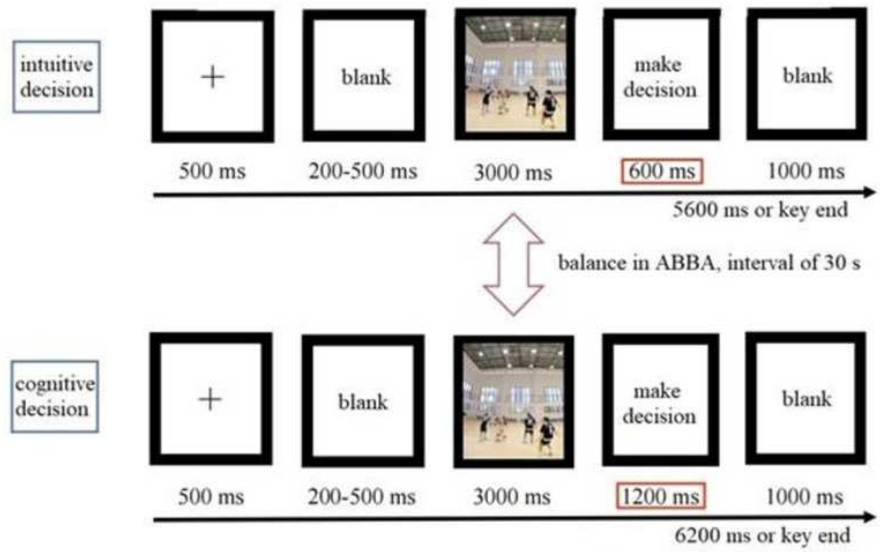


Figure 2 Basic process of sports decision-making task

Figure 3

Figure 3 Tracking accuracy of MOT at different speeds for experts and novices

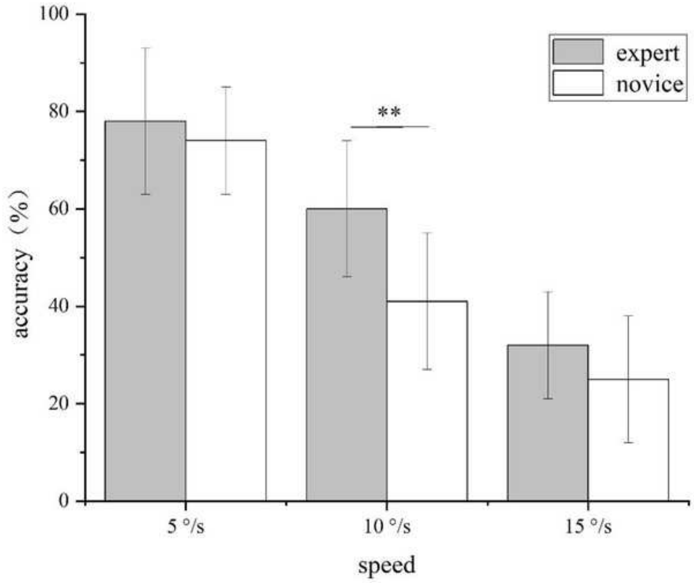


Figure 3 Tracking accuracy of MOT at different speeds for experts and novices