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Exploring the Gaze Behavior of Tennis Players with Different Skill Levels When Receiving Serves through Eye Movement Information

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Abstract: Background: The purpose of this study was to explore the gaze behavior of tennis players with different skill levels when receiving serves through eye movement information. Methods: The skill level was divided into group A (experts, with more than 10 years of playing experience) and group B (novices, with less than 2 years of playing experience). We compared the differences in gaze behavior between groups A and B at the head-shoulder, trunk-hips, arm-hand, leg-foot, racket, ball, and racket-ball contact area seven positions using the Eye-gaze Response Interface Computer Aid (ERICA) device. Data were analyzed using two-way ANOVA. Results: Compared with the novices, the experts have more gaze time in the head–shoulders, rack, and ball when serving forehand ($p < 0.01$). The experts also have more gaze time on the head–shoulders, trunk–hips, racket, ball, and racket–ball contact area when serving backhand ($p < 0.05$). Conclusions: Expert athletes have a longer stare time for a specific position, which mainly determines the direction of the ball. Tennis coaches can increase the gaze time for these four positions and improve tennis players' ability to predict the direction of the ball.

Keywords: visual search; tennis; gaze behavior; perceptual-motor performance

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1. Introduction

In tennis, the strategy of receiving and serving has become increasingly important [1]. Receiving serves is one of the factors that determines the outcome of a tennis match [2]. Past studies have analyzed three former world number one tennis players, showing that receiving a served ball provides a counterattack option [3]. Therefore, in tennis to improve the ability to receive service is one of the keys to improve the performance in the game. Perceptual skill is fundamental to successful performance in fast-ball sports, such as tennis. Skilled tennis players must perceive and interpret information in a quick and effective manner, thereby providing sufficient time to plan, initiate, and execute a successful return shot [4]. To investigate an expert's perceptual skill, researchers have examined the anticipatory visual cues expert players use in a variety of activities, including tennis [5]. Study has shown that expert tennis players have a shorter reaction time, shorter movement time, and higher accuracy of ball outcome anticipation than novice players [6]. In this study, a serve at the forehand gaze and backhand gaze will be evaluated for different levels of players, with a specific focus on comparisons between the experts and novices.

According to the human message processing model theory, stimulus identification involves information received by the body's sight, hearing, touch, and smell organs. Through these senses, external messages are delivered to the brain [7]. Among the different types of stimuli, visual information is the most important, and athletes need a certain reaction time to make a correct decision when they receive action information from their opponents [8]. Research shows that high-performance visual search strategies can enhance decision-making capabilities through better recognition patterns and capturing important messages from opponents' body positions [9].

A previous study found that excellent handball goalkeepers need accurate gaze search capabilities, the ability to receive a shooter's action message visually, and the ability to analyze the sphere flight trajectory to intercept the opponent's ball [10]. Therefore, in a fast-sporting event, the effective receipt of action messages and conditions expected in the context of impending movement will help to enhance performance. By studying gaze behavior when receiving a tennis serve, one study found that excellent players have faster decision-making responses than ordinary players [11]. Further, there were more fixation gazes with visual fixation, and the duration of fixation was very long. Noel and Van Der Kamp reported that excellent football players make faster decisions than general players [12]. In the sport of football, top players have a longer gaze than ordinary players. Related research regarding the importance of gaze includes analyses of closed kinetic chain exercises, such as golf putting [13], basketball shooting [14], and dart throwing [15]; perceptual anticipation during open kinetic chain exercises, such as pistol shooting [13,16] and soccer penalties; and the position of hockey goalkeepers and ice hockey referee defensive strategies or messages [17,18]. Therefore, timely, and accurate access to visual information is very important to improve athletes' training and competition level.

The gaze position before an action can be considered important regarding the best players' expected behavior [19]. For example, during a goalkeeper blockade, visual behavior identifies the shooter's foot swing, the angle of the support foot, the location of the ball and racket, and so on, before the opponent moves. An excellent player will use the collected visual information as an important factor in predicting the ball's trajectory. Therefore, it is important to understand performance expectations and decision characteristics of players at different levels.

Another study compared the performance of sport experts and novices when one object was at fixation and the other one in the periphery, to a condition in which both objects were in the periphery and subjects fixated between them. It suggests that sport experts consistently outperformed novices in both fixation strategies [20]. Identifying the information that is primarily responsible for judging gaze is a way for players to train and improve their performance skills. Past studies have found significant differences in stroke accuracy between tennis players on the forehand and backhand racket, and less diversity in backhand receiving serves than forehand receiving serves in men's professional games [21,22]. Based on this theory, it is expected that experts will have longer saccade amplitudes to cover more areas and will take less time to fixate on task-relevant areas [23]. In sports, expert judges in rhythmic gymnastics were reported to use shorter fixation durations on the scene for error-detection in the performance of the gymnasts [24]. Therefore, the purpose of this study was to explore the gaze behavior of tennis players at different skill levels when receiving serves through eye movement information. It is hypothesized that expert athletes have longer gaze times at a specific locations than novice athletes; a longer gaze time may help to determine the direction of a ball and provide reference for coaches and athletes.

2. Materials and Methods

2.1. Study Design

This study used the Eye-gaze Response Interface Computer Aid (ERICA) device. This system has been used to show that when receiving a serve, excellent players watch for pitch clues, successfully predict the direction of the ball via their opponent's gaze behavior, and can anticipate opposing players' thoughts before they act by observing visual behavior. This study involved movie watching experiments in the laboratory. The test method in this study is that tennis players watch a serve video, and the position is relatively undisturbed by the laboratory environment.

2.2. Participants

Using a recruitment announcement, this study recruited 10 college males who were training as a group as the research subjects. The players were split into two groups. The top 5 players, who had more than 10 years of tennis training, were assigned as experts (age 20.6 ± 1.1 years, training age 10.2 ± 1.1 years). The 5 remaining individuals, who had less than 2 years of tennis training, were assigned as the novices (age 20.0 ± 0.4 years, training age 1 ± 0.5 years). A priori power analysis (G*Power version 3.1.9.4; Heinrich Heine University Düsseldorf, Düsseldorf, Germany) showed that a minimum of 10 participants was required based on conventional α (0.05) and β (0.95) values and an effect size of 4.08. Participants attended a single testing session and, after reviewing written information about the study, each provided written informed consent. Pupil correction, using a cross cursor (1° angle of visual sense shot with 4.5 mm lens) was viewed in real-time scene on a laptop and recorded [25].

2.3. Experimental Equipment

A Mobile Eye ASL Mexg (Bedford, MA, USA) portable eye tracker was used to track eye movement. The principle of corneal reflection monocular tracking involves the capture of eye tracking images, for which the video data were stored on a hard drive. The sampling frequency was 30 Hz, the accuracy was ≤0.5, the resolution was ≤0.10, the horizontal angle of view was 50 degrees, and the vertical angle was less than 40 degrees. Gaze Tracker analysis software was run on a Vista Home Basic/Intel Dual Core system computer, which was used to collect data from the eye tracking device and generate the number of gaze positions and time data.

Although some visual search studies have shown differences between lab-based tasks and actual experimental designs, the same movie model was used to ensure that all participants watched the serve at the same time [26]. The participants' gaze reactions to the serve were monitored to determine the stare duration and the gaze position (in Figure 1).

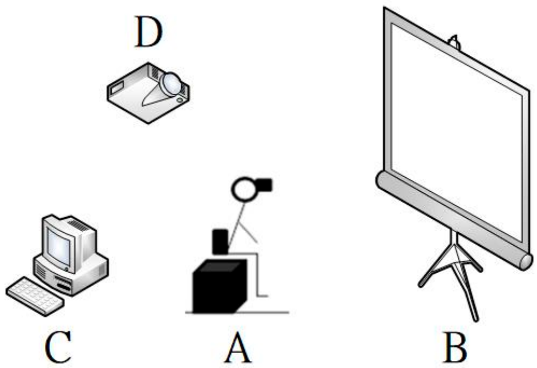


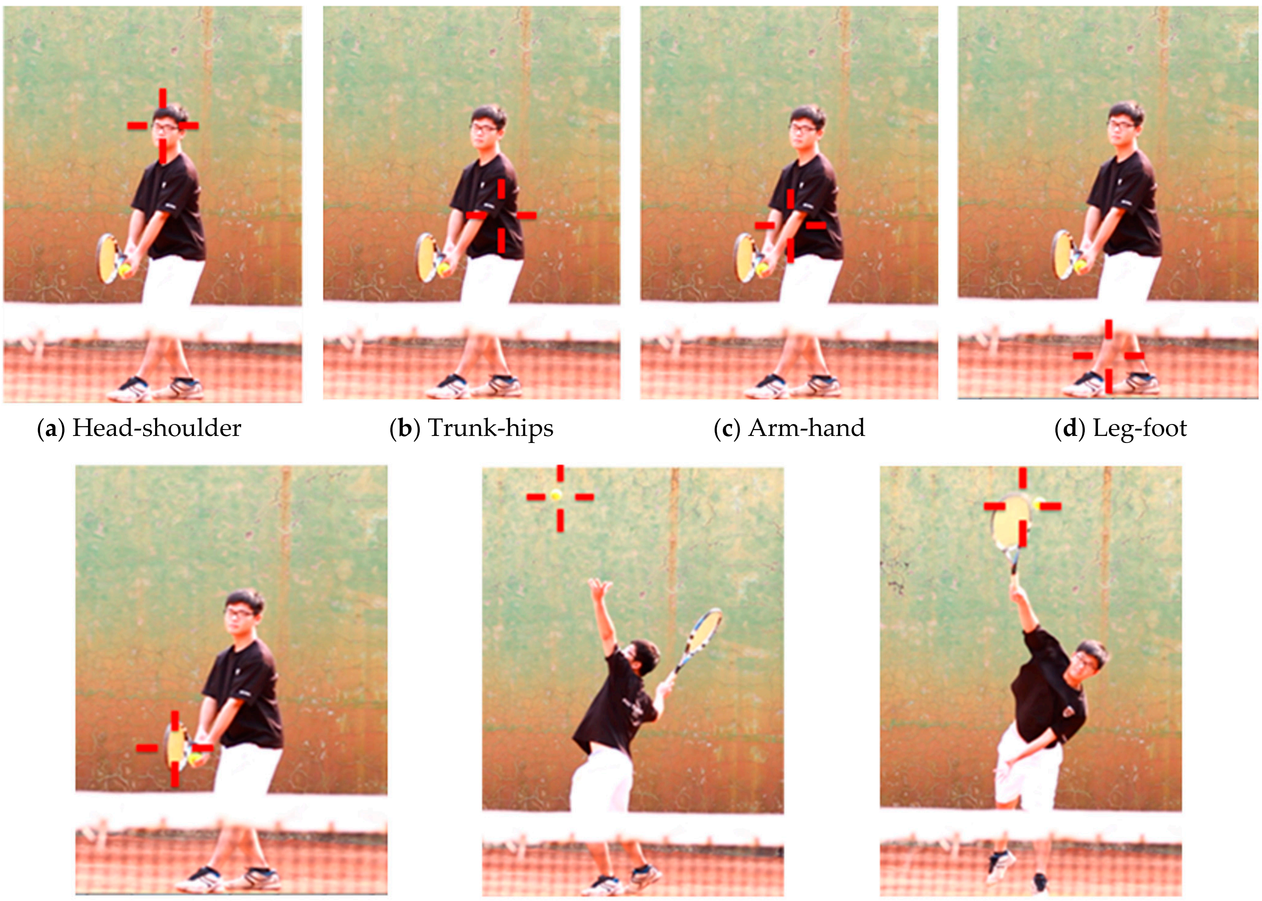
Figure 1. Experimental setup ((**A**) eye tracker, (**B**) projection screen, (**C**) investigator control computer, (**D**) projector).

2.4. Procedure

The experimental process was explained prior to testing, and then computer-assisted pupil correction was implemented; the correction value was required to be greater than 80% and less than the standard for re-calibration to occur. During the experimental process, if the instrument was touched, causing inaccuracy, the experiment was stopped and re-calibration was performed. If subject's pupil information or other calibration data were not able to be retrieved, the subject rested and was then re-processed. Participants were asked to watch the serve and had their own tennis court to compete with the athlete's serve on the video. As in a regular tennis tournament, the situation involved serving the ball during a game, which included thinking and imagining the most effective pick-and-roll movements that would make it difficult for the server to respond. If the participant understood the instructions, they watched three randomly presented serves and were given time to adapt to the film. After the 3 serves, if the participant had no questions, they received another calibration and finished the entire test. After completing this portion of the experiment, the participants were placed in front of a rear projection screen. The viewing position was 4 m away from the projection screen, sitting in the center of the projection screen, first practice receiving 3 balls, and then formally start to receive 10 balls (5 randomly shot balls on the front and back).

The server was randomly located on the subject's left side and completed a total of 10 serves, including 5 forehand and backhand positions and the serve in a teeing area that was 1.5 m long and 1.5 m wide. The ball speed was (160 $\pm$ 5 km/h) measured from the front. A video recorder (Sony Handy-Cam HDR-XR550VE) and radar gun (JUGS, R-1000) were placed 1 m behind the baseline of the singles court and 175 cm above the ground (average player height). When asking participants to watch the serve video, they were asked to imagine that they were playing on the tennis court and how to effectively return the serve. Projection was from the rear projector (EPSON EMP-S3 3 LCD Projector) to the projection screen (1.8 m high and 2 m wide). The average length of time per serve was 6130 ms (SD = 0.82). The longest serve was 6950 ms. The participants sat in front of the center of the projection screen and first viewed 3 practice balls, which were followed by the start of the 10 official balls (random positive and negative shots for 5 of the balls). After each serve was completed, the participant waited in place for the next ball.

Gaze positions: the gaze positions in video image of the scene are based on the seven more important gaze positions suggested by a past study [5]: (a) head–shoulder, (b) trunk–hips, (c) arm–hand, (d) leg–foot, (e) racket, (f) ball, (g) racket–ball contact area. The items listed above are named as regions of interest (RoIs); the seven RoIs of a player's body were classified using a "cross cursor" (in Figure 2) for this study [27].



(**a**) Head-shoulder (**b**) Trunk-hips (**c**) Arm-hand (**d**) Leg-foot

(**e**) Racket (**f**) Ball (**g**) Racket-ball Contact Area

Figure 2. Body division on seven ROIs.

2.5. Statistical Analysis

All data obey normal distribution, descriptive and outcome statistics are presented as the means ± SD. Using a mixed-design two-way repeated-measures analysis of variance (ANOVA) considering the position- point (seven gaze positions) as a within-subject effect and the group (experts and novices' group) as a between-subject effect. A p-value < 0.05 was considered statistically significant. Given the small sample sizes (<50 samples) of this study, the Shapiro–Wilk was used to test normality. The null hypothesis means that the data is taken from a normally distributed population, it is accepted when $p > 0.05$ and the data obeys the normal distribution in this study [28]. Cohen's d was often used to estimate effect size and thereby evaluate clinical and practical sense [29]. Effect size calculations were based on the Cohen's d statistic as the following formula (d = [Mexpert − Mnovice]/SDnovice). Cohen categorized ES values as small (ES: 0.2–0.5), moderate (ES: 0.5–0.8), and large (ES: >0.8) [30].

3. Results

3.1. Gaze Behavior during a Forehand Serve

Table 1 provides the forehand gaze average time for each group for the fixation locations. The data showed that there was a significant interaction effects (position * groups) in different levels of forehand players ($p < 0.01$). Figure 3 shows the simple main effect of forehand gaze time between different level players. Specifically, compared with novices, experts have significant differences in the head-shoulders (HS) ($p = 0.001$, ES = 4.51), rack ($p < 0.001$, ES = 3.95), and ball ($p = 0.001$, ES = 3.91). However, there is no significance difference in the trunk-hips (TH) ($p = 0.489$, ES = 0.46), arm-hand (AM) ($p = 0.106$, ES = 1.15), leg-foot (LF) ($p = 0.256$, ES = 0.83), and racket-ball contact area (RB) ($p = 0.069$, ES = 1.55).

Table 1. Forehand gaze time (average and standard deviation) for tennis players of different skill levels.

	Head-Shoulder	Trunk-Hips	Arm-Hand	Leg-Foot	Racket	Ball	Racket-Ball Contact Area
Experts	1.55 ± 0.29	1.77 ± 0.16	0.39 ± 0.16	0.24 ± 0.33	0.79 ± 0.12	2.23 ± 0.38	0.07 ± 0.06
Novices	0.59 ± 0.09	1.68 ± 0.21	0.20 ± 0.16	0.04 ± 0.06	0.22 ± 0.17	1.05 ± 0.19	0.003 ± 0.01

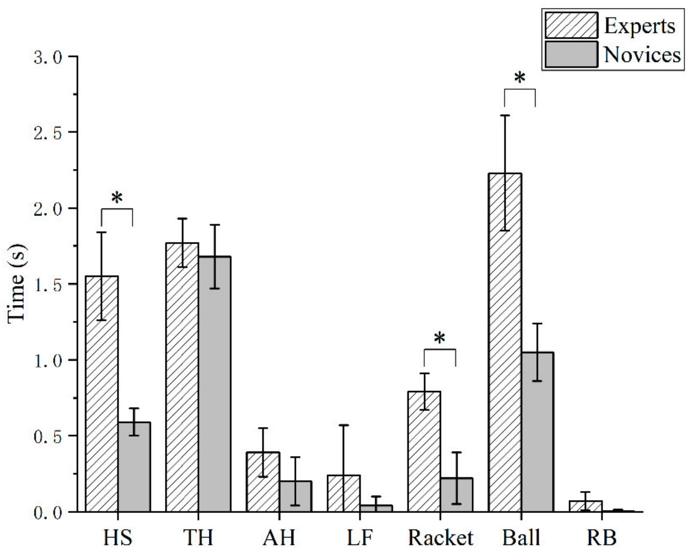


Figure 3. Gaze time for different positions during a forehand shot for tennis players of different skill levels. Gaze time for different positions during a backhand shot for different skill level tennis players; HS: head–shoulder, TH: trunk–hips, AH: arm–hand, LF: leg–foot; RB: racket–ball. *: Statistically significant difference between experts and novices.

3.2. Gaze Behavior during a Backhand Serve

Table 2 provides the average backhand gaze time for each group for the fixation locations. The data showed that there was a significant interaction effects (position * groups) in different levels of backhand players ($p < 0.001$). Figure 4 shows the simple main effect of backhand gaze time between different level players. Specifically, compared with novices, experts have significant differences in the head–shoulders (HS) ($p < 0.001$, ES = 7.69), trunk–hips (TH) ($p < 0.001$, ES = 4.97), racket ($p = 0.002$, ES = 3.64), ball ($p = 0.001$, ES = 4.41), and racket–ball contact area (RB) ($p = 0.017$, ES = 2.35). However, no significant difference was found in the arm–hand (AH) ($p = 0.085$, ES = 1.34) and leg–foot (LF) ($p = 0.069$, ES = 1.51).

Table 2. Backhand gaze time (average and standard deviation) for tennis players of different skill levels.

	Head–Shoulder	Trunk–Hips	Arm–Hand	Leg–Foot	Racket	Ball	Racket–Ball Contact Area
Experts	1.46 ± 0.18	1.31 ± 0.20	0.37 ± 0.22	0.19 ± 0.15	1.12 ± 0.13	2.17 ± 0.54	0.08 ± 0.04
Novices	0.18 ± 0.15	0.28 ± 0.21	0.15 ± 0.09	0.02 ± 0.03	0.24 ± 0.31	0.37 ± 0.21	0.01 ± 0.01

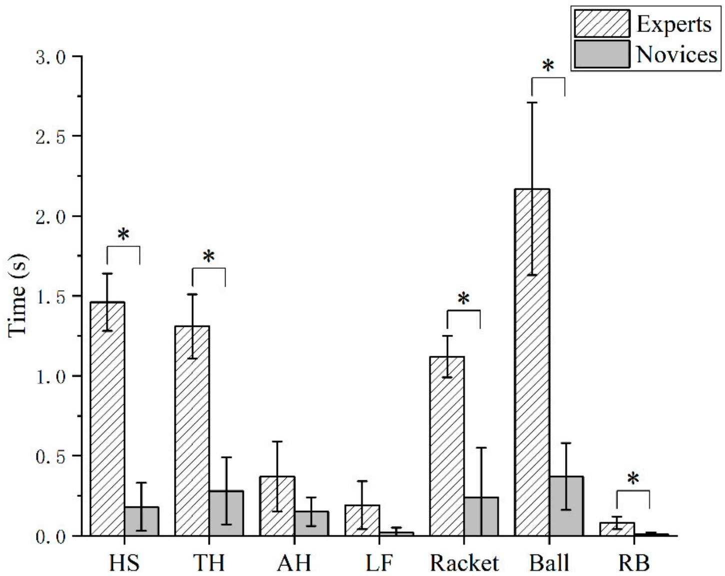


Figure 4. Gaze time for different positions during a backhand shot for different skill level tennis players. HS: head–shoulder, TH: trunk–hips, AH: arm–hand, LF: leg–foot; RB: racket–ball. *: Statistically significant difference between experts and novices.

Overall, the longest gaze time for both groups was at the ball and the shortest gaze time was at the racket–ball contact area.

4. Discussion

Forehand gaze. The results showed that players of different skill levels differ in terms of their gaze position. Specifically, the experts and novices differed in terms of the duration of gaze at the ball, racket, head, and shoulder positions, which shows that these four positions are more important when receiving a serve. Past studies found that excellent players will watch all general body positions [11,26]. Additionally, the results indicate that the gaze time differed significantly between experts and novices. Experts gaze at the contact of the racket and the ball for a while when receiving the ball. The experts had a longer gaze time in this position, likely because the moment of contact with the ball is used determine the ball's direction. Usually, athletes need to gaze at more positions in the process of receiving service, so they will not gaze at important positions in the distribution process. The experts have a longer gaze time in important moments, which indicates that the ability to receive important information is better. The findings regarding differences in gaze behavior also provides an explanation for differences between novices and experts in terms of movement and pressure during rifle shooting [15,31], basketball free throw performance [32], and other processes. The final fixation time of expert players was also longer than that of novices, indicating that when receiving the ball, different levels of tennis players have a different gaze time gaps. Given that how the ball leaves the racket determines the final direction of the ball, gazing at the racket–ball contact position becomes an important clue for an experienced receiver. Experts will stare at important positions, which comes from long-term training. Excellent players wait until there is enough information to determine the direction of the ball and then swing, in anticipation of hitting the ball accurately [33]. It was found that the average group spent more time gazing at the ball and trunk–hips positions during the gaze, and almost none at head–shoulder, trunk–hips, arm–hand, leg–foot, racket, ball and racket–ball positions during the rest of the gaze. This is in line with previous studies where good tennis players spent more time gazing at the ball on serve than the average player [2].

Backhand gaze. The serve from the backhand position was evaluated for different levels of players, with a specific focus on comparisons between experts and novices. The gaze was longer at the racket, ball and racket–ball contact areas with experts than with novices, which indicates that it may be important to focus on these three locations during training. The experts exhibited a significantly longer gaze time at the ball for the hands, legs, racket, and racket–ball contact area positions. Further, the gaze time at the shoulder was longer than that at the hand and the racket–ball contact areas. Generally, there is no significant difference in the different positions between the groups. This may be due to the inability to confirm an important position when receiving the serve, resulting in no difference. Unskilled players tend to be uncertain about the position of their gaze. On the contrary, experts will have a fixed gaze position and get used to staring at the ball in the last few seconds [34]. The results for novices are consistent with the results for experts. The final fixation of expert players was longer than that of novices. The above results show significant differences between the experts and novices in terms of gaze time. Specifically, for the experts, the gaze time at the racket–ball contact area position was higher than that for the novices. The ball's location and direction on the racket are the final cue from the ball to the serve receiver. Inexperienced players tend to focus their attention on post-swing action, especially on the racket end [35], as opposed to high-skill players, who based on their experience, receive messages to be able to more accurately predict subtle changes in serves [36]. The experts showed a longer gaze time when analyzing the ball's trajectory.

This study revealed the gaze behavior of tennis players of different skill levels when receiving serves through eye movement information. However, there are some limitations that should be addressed in future research. First, in this study, there is a lack of more targeted and informative guidance during the entire task execution process, and no analysis of the underlying mechanisms of visual perception, which is very important for understanding visual cognitive activities. In addition, the designed on-court task may not fully represents what is like to return a tennis serve. Future studies should take advantage of developing technology that will allow analysis of complete rallies, in which players can perform a variety of shots, providing a fully locationally valid study of gaze behaviors in tennis. Although calibration issues and a very time-consuming analysis will be expected for more complex tasks, these changes in methodology are required to further discern the gaze behavior characteristics, leading to successful performance and expertise-based differences in tennis.

5. Conclusions

In this study, we collected data to analyze tennis gaze times for the head–shoulder, trunk–hips, arm–hand, leg–foot, racket, ball, and racket–ball contact area positions. These seven locations exhibited significant differences in terms of gaze time for experts, who had significantly higher values than novices. For the forehand serve gaze positions, the gaze times at the head–shoulder, racket, ball, and racket–ball contact area were higher in experts than in novices. The gaze times for the backhand serve were higher at the racket–ball contact area in the experts than in novices. In conclusion, these findings indicate that observing the ball to determine its direction is important and indicates that receiving and training players can practice to increase their gaze duration at this position. Future research can further improve the ecological validity of the research results in an outdoor stadium environment. The new technology of portable eye-tracking glasses can provide more accurate insights into these issues.

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References

1. Hizan, H.; Whipp, P.; Reid, M.; Wheat, J. A comparative analysis of the spatial distributions of the serve return. *Int. J. Perform. Anal. Sport* **2014**, *14*, 884–893. [CrossRef]
2. Sáenz-Moncaleano, C.; Basevitch, I.; Tenenbaum, G. Gaze Behaviors during Serve Returns in Tennis: A Comparison between Intermediate-and High-Skill Players. *J. Sport Exerc. Psychol.* **2018**, *40*, 49–59. [CrossRef] [PubMed]
3. Mergheş, P.E.; Simion, B.; Nagel, A. Comparative Analysis of Return of Serve as Counter-attack in Modern Tennis. *Timis. Phys. Educ. Rehabil. J.* **2014**, *6*, 18–22. [CrossRef]
4. Williams, A.M.; Ward, P.; Smeeton, N.J.; Allen, D. Developing anticipation skills in tennis using on-court instruction: Perception versus perception and action. *J. Appl. Sport Psychol.* **2004**, *16*, 350–360. [CrossRef]
5. Ward, P.; Williams, A.M.; Bennett, S.J. Visual search and biological motion perception in tennis. *Res. Q. Exerc. Sport* **2002**, *73*, 107–112. [CrossRef]
6. Singer, R.N.; Cauraugh, J.H.; Chen, D.; Steinberg, G.M.; Frehlich, S.G. Visual search, anticipation, and reactive comparisons between highly-skilled and beginning tennis players. *J. Appl. Sport Psychol.* **1996**, *8*, 9–26. [CrossRef]
7. Schmidt, R.; Lee, T. *Motor Control and Learning*, 5th ed.; Human Kinetics: Champaign, IL, USA, 1998; Volume 23.
8. Vickers, J.N. Neuroscience of the quiet eye in golf putting. *Int. J. Golf Sci.* **2012**, *1*, 2–9. [CrossRef]
9. Piras, A.; Pierantozzi, E.; Squatrito, S. Visual search strategy in judo fighters during the execution of the first grip. *Int. J. Sports Sci. Coach* **2014**, *9*, 185–198. [CrossRef]
10. Loffing, F.; Hagemann, N. Skill differences in visual anticipation of type of throw in team-handball penalties. *Psychol. Sport Exerc.* **2014**, *15*, 260–267. [CrossRef]
11. Goulet, C.; Bard, C.; Fleury, M. Expertise differences in preparing to return a tennis serve: A visual information processing approach. *J. Sport Exerc. Psychol.* **1989**, *11*, 382–398. [CrossRef]
12. Noel, B.; Van Der Kamp, J. Gaze behaviour during the soccer penalty kick: An investigation of the effects of strategy and anxiety. *Int. J. Sport Exerc. Psychol.* **2012**, *43*, 326.
13. Vickers, J.N.; Lewinski, W. Performing under pressure: Gaze control, decision making and shooting performance of elite and rookie police officers. *Hum. Mov. Sci.* **2012**, *31*, 101–117. [CrossRef]
14. Steciuk, H.; Zwierko, T. Gaze behavior in basketball shooting: Preliminary investigations. *Trends Sport Sci.* **2015**, *22*, 89–94.
15. Nibbeling, N.; Oudejans, R.R.; Daanen, H.A. Effects of anxiety, a cognitive secondary task, and expertise on gaze behavior and performance in a far aiming task. *Psychol. Sport Exerc.* **2012**, *13*, 427–435. [CrossRef]

16. Chirico, A.; Fegatelli, D.; Galli, F.; Mallia, L.; Alivernini, F.; Cordone, S.; Giancamilli, F.; Pecci, S.; Tosi, G.M.; Giordano, A. A study of quiet eye's phenomenon in the shooting section of "laser run" of modern pentathlon. *J. Cell. Physiol.* **2019**, *234*, 9247–9254. [CrossRef]
17. Hancock, D.J.; Ste-Marie, D.M. Gaze behaviors and decision making accuracy of higher-and lower-level ice hockey referees. *Psychol. Sport Exerc.* **2013**, *14*, 66–71. [CrossRef]
18. Hüttermann, S.; Memmert, D.; Liesner, F. Finding the happy medium: An analysis of gaze behavior strategies in a representative task design of soccer penalties. *J. Appl. Sport Psychol.* **2014**, *26*, 172–181. [CrossRef]
19. Fegatelli, D.; Giancamilli, F.; Mallia, L.; Chirico, A.; Lucidi, F. The use of eye tracking (ET) in targeting sports: A review of the studies on quiet eye (QE). In *Intelligent Interactive Multimedia Systems and Services 2016*; Springer: Berlin/Heidelberg, Germany, 2016; pp. 715–730.
20. Hüttermann, S.; Memmert, D.; Simons, D.J.; Bock, O. Fixation strategy influences the ability to focus attention on two spatially separate objects. *PLoS ONE* **2013**, *8*, e65673. [CrossRef]
21. Kovalchik, S.; Reid, M. A shot taxonomy in the era of tracking data in professional tennis. *J. Sports Sci.* **2018**, *36*, 2096–2104. [CrossRef] [PubMed]
22. Delgado-García, G.; Vanrenterghem, J.; Muñoz-García, A.; Ruiz-Malagón, E.J.; Mañas-Bastidas, A.; Soto-Hermoso, V.M. Probabilistic structure of errors in forehand and backhand groundstrokes of advanced tennis players. *Int. J. Perform. Anal. Sport* **2019**, *19*, 698–710. [CrossRef]
23. Gegenfurtner, A.; Lehtinen, E.; Säljö, R. Expertise differences in the comprehension of visualizations: A meta-analysis of eye-tracking research in professional domains. *Educ. Psychol. Rev.* **2011**, *23*, 523–552. [CrossRef]
24. Flessas, K.; Mylonas, D.; Panagiotaropoulou, G.; Tsopani, D.; Korda, A.; Siettos, C.; Di Cagno, A.; Evdokimidis, I.; Smyrnis, N. Judging the judges' performance in rhythmic gymnastics. *Med. Sci. Sports Exerc.* **2015**, *47*, 640–648. [CrossRef] [PubMed]
25. Vine, S.J.; Moore, L.; Wilson, M.R. Quiet eye training facilitates competitive putting performance in elite golfers. *Front. Psychol.* **2011**, *2*, 8. [CrossRef]
26. Murray, N.P.; Hunfalvay, M. A comparison of visual search strategies of elite and non-elite tennis players through cluster analysis. *J. Sports Sci.* **2017**, *35*, 241–246. [CrossRef] [PubMed]
27. Carneiro, A.T.S.; do Lago, O.C.; Schor, P. Analysis of Gaze Patterns for Understanding Behaviour of Professional Tennis Players. 2016. Available online: https://www.researchgate.net/profile/Olival-Do-Lago/publication/315717920_Analysis_of_Gaze_Patterns_for_Understanding_Behaviour_of_Professional_Tennis_Players/links/58de71bea6fdcc1772e1df30/Analysis-of-Gaze-Patterns-for-Understanding-Behaviour-of-Professional-Tennis-Players.pdf (accessed on 8 September 2021).
28. Mishra, P.; Pandey, C.M.; Singh, U.; Gupta, A.; Sahu, C.; Keshri, A. Descriptive statistics and normality tests for statistical data. *Ann. Card. Anaesth.* **2019**, *22*, 67.
29. Fritz, C.O.; Morris, P.E.; Richler, J.J. Effect size estimates: Current use, calculations, and interpretation. *J. Exp. Psychol. Gen.* **2012**, *141*, 2. [CrossRef]
30. Hojat, M.; Xu, G. A visitor's guide to effect sizes–statistical significance versus practical (clinical) importance of research findings. *Adv. Health Sci. Educ. Theory Pract.* **2004**, *9*, 241–249. [CrossRef]
31. Causer, J.; Bennett, S.J.; Holmes, P.S.; Janelle, C.M.; Williams, A.M. Quiet eye duration and gun motion in elite shotgun shooting. *Med. Sci. Sports Exerc.* **2010**, *42*, 1599–1608. [CrossRef]
32. Wilson, M.R.; Wood, G.; Vine, S.J. Anxiety, attentional control, and performance impairment in penalty kicks. *J. Sport Exerc. Psychol.* **2009**, *31*, 761–775. [CrossRef]
33. Shim, J.; Miller, G.; Lutz, R. Visual cues and information used to anticipate tennis ball shot and placement. *J. Sport Behav.* **2005**, *28*, 186.
34. Vickers, J.N. *Perception, Cognition, and Decision Training: The Quiet Eye in Action*; Human Kinetics: Champaign, IL, USA, 2007.
35. Abernethy, B. Searching for the minimal essential information for skilled perception and action. *Psychol. Sci.* **1993**, *55*, 131–138. [CrossRef] [PubMed]
36. Runeson, S. Perceiving people through their movements. In *Individual Differences in Movement*; Springer: Berlin/Heidelberg, Germany, 1985; pp. 43–66.