Original Article

Comparison of the gaze behavior of soccer referees of different levels

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Abstract:

A referee can achieve a higher level in the career if he/she can develop perceptual-cognitive skills related to expert-performance. We believe that this adaptation may be related to the improvement of their gaze behavior in the search for the relevant cues and quality of the decision making in a game situation. However, this hypothesis has not been tested in referees of national and state-level. The present study aimed to compare the gaze behavior of Brazilian referees of national and state-level through the analysis of the quantity and duration of gaze fixations and the quality of decision making. Nineteen Brazilian soccer referees (16 men and three women) from the Confederação Brasileira de Futebol (CBF – national level) and Federação Mineira de Futebol (FMF – state level) participated in the study. Thirteen referees were center referees, while three were assistants. Gaze behavior was analyzed during the visualization of soccer scenes using an Eye-tracking SMI RED500® device. Situations of fouls, enforcement of yellow and red cards, and offside rule were used to analyze the quality of the decision making. An independent t-test was used to compare the gaze behavior variables and the quality of decision making between groups. National referees presented shorter gaze fixations ($p = .003$; large effect size), but there were no differences for decision making ($p = .146$; medium effect size). We concluded that Brazilian soccer referees from state and national levels differ in their visual strategies during game situations although that does not influence their quality of decision on rule infractions. The higher efficiency found in higher-level referees is evidenced by their shorter gaze fixations, which suggests they can perceive relevant cues more quickly.

Key Words: Cognition, Decision Making, Perception, Eye Tracking, Performance.

Introduction

Soccer referees play an important role in the regulation of athletes' behavior during a match, by judging and deciding according to the rules of the game. These judgments and decisions are supported by cognitive processes (attention, anticipation, perception, option generation, decision making) and contextual and environmental aspects, such as the available time within each situation (Raab, 2007; Larkin, Mesagno, Berry, & Spittle, 2018).

During the match, referees' decisions are constantly influenced by their visual field, due to the direction of motion and angle of vision (Huttermann, Noel, & Memmert, 2017; Kranjec, Lehet, Bromberger, & Chatterjee, 2010). The visual search for environmental information (relevant cues) is based on cognitive processes that allow the referee to recognize situation patterns and make appropriate decisions (Abdeddaim, Sebbane, Zitouni, Zubiaur, & Boumesdji, 2016; Van Maarseveen, Oudejans, Mann, & Savelsbergh, 2016), such as in rule infraction. Therefore, the investigation on the gaze behavior of referees in game situations, such as the duration and the number of visual fixations captured by eye-tracking systems, will provide important information for the understanding of the phenomenon of decision making by soccer referees (Catteeuw, Helsen, Gilis, Van Roie, & Wagemans, 2009; Spitz, Put, Wagemans, Williams, & Helsen, 2016).

Within the sport context, previous studies have shown differences in the gaze behavior between expert and novice athletes (Krzepota, Stepinski, & Zwierko, 2016; Klostermann & Moeinirad, 2020). In soccer, expert athletes showed shorter gaze fixations, as well as a higher number of fixations and better decision making than novices (Krzepota et al., 2016; Lex, Essig, Knoblauch, & Schack, 2015). On the contrary, previous research that analyzed the gaze behavior of referees of different competitive levels (national and international) (Catteeuw et al., 2009; Hancock & Ste-Marie, 2013) did not find differences between referees of different levels. Nevertheless, there is evidence that referees of higher competitive levels (international) or experience make more appropriate decisions compared to referees of lower competitive levels (Spitz, Put, Wagemans, Williams, & Helsen, 2018). In that case, the highly similar characteristics of the two groups, such as age, time of practice, and level of competition that they take part (Memmert, Simons, & Grimme, 2009) may have hindered the finding of significant differences between groups.

In Brazil, referees are divided into three competitive levels: state, national, and international. National-level referees take part in championships involving national teams (e.g., Brazilian championship – “Brasileirão”), while state-level referees take part in championships involving regional teams within the state (e.g., state championship of Minas Gerais). The referees’ progression to the higher levels of competition is determined by their time of experience, age, and performance in official matches. During the progression, referees are demanded to improve their skills, adapting to higher game levels. We believe that this adaptation may be related to the improvement of their gaze behavior in the search for the relevant cues within a game situation. However, this hypothesis has not been tested. The identification of differences in the gaze behavior of referees of different competitive levels may contribute to the improvement of the teaching-learning process of refereeing and, consequently, the referees’ performance and decision making during official matches (Broadbent, Causer, Williams, & Ford, 2015; Kredel, Vater, Klostermann, & Hossner, 2017). Considering the aforementioned issues, this study aimed to compare the gaze behavior and decision making between Brazilian referees of national (higher-level group) and state levels (lower level group). We hypothesized that higher level referees would differ from lower-level referees for gaze behavior and present better decision making.

Material & methods

Participants

Nineteen Brazilian soccer referees (16 men and 3 women) from the Brazilian Soccer Confederation (CBF) and Minas Gerais Soccer Federation (FMF) participated in the study. Thirteen referees were center referees, while 3 were assistants. The referees were divided into two groups, according to their competitive level, as shown in table 1. The participants received full information on the research procedures and gave written consent to participate in the study. This study followed all guidelines of the Helsinki declaration and was approved by the local Ethics committee. Table 1 presents the main characteristics of the sample of the current study.

Table 1. Referees’ characteristics within the two groups.

	G1 (National)	GS (State)
Number of main referees (n)	6 (men)	7 (mem)
Number of assistant referees (n)	2 (women)	4 (one woman and four men)
Age (years)	30.6 ±4.7	30.4 ±5.5
Time of experience (years)	11.1 ±4.2	8.5 ±5.4

(±) – standard deviation

Test protocol

Twenty-one soccer scenes comprising fouls (15) and out of bounds (6) situations were used in the study. These scenes were selected from a FIFA (Fédération Internationale de Football Association) collection of videos used in referees’ courses and training. The scenes were edited using the *Freemaker Video Converter* software so that the referees on the scenes could not be seen, neither their decisions. The participants declared no previous knowledge about the selected scenes. Scenes of the Brazilian national team were excluded, to avoid bias in the participants’ answers. All the scenes lasted 35 seconds and were showed to participants from four visual angles. At the end of the scene, participants should make their decision.

Instruments

The scenes files were added into the Experiment Center 3.5, the software used to analyze data provided by the Eye Tracking SMI RED500® (SensoMotoric Instruments – SMI). The eye-tracking is an equipment used to identify and record eye movements within controlled or natural environments. It records the eye movements at a 250 Hz sampling rate through an infrared laser scanner fixed to the computer screen. The variables related to gaze behavior (number and duration of gaze fixations) were calculated using the software Experiment Center 3.5, which has been used previous research on visual tasks (Castro et al., 2019; Castro, Praça, Costa, Pedrosa, & Greco, 2016; Costa et al., 2018).

Procedures

Firstly, participants filled in a questionnaire comprising information on their age, time of experience at refereeing, the competitive level they refereed, number of games per week they worked as referees, and number and duration of refereeing practice within a week. During data collection, only the participant and the evaluator were present in the room. Participants sat comfortably on a chair in front of a computer (60 cm apart) to watch the game scenes. Before the commencement of the test, the evaluator explained to the participant that the test included situations of fouls and out-of-bounds and that decision options would be displayed right after the end of each scene. Participants were also informed about the total duration of the test (approximately 30 minutes) and advised not to move their face and neck, to avoid the miscalibration of the equipment. After this explanation, the Eye Tracking equipment was calibrated according to the position of participants’ eyes, using the iView X RED

500Hz software, recommended by the manufacturer for calibration. During the test, the referees should quickly choose an option (within 10 seconds) by pressing the “space” key on the computers’ keyboard, automatically moving to the next scene until the end of the test. The first two scenes of the test were used for participants’ familiarization. At this moment, they could clarify any doubts by asking them to the evaluator. The test scenes were presented to the participants in random order.

The screen with the decision-making options after each scene showed the question “What decision should be made?”. For the foul scenes, the options distributed over two columns: the left one with 4 foul situations (direct free-kick, indirect free-kick, “penalty kick”, or “no foul”) and the right one with the sanctions that could be applied: “yellow card”, “red card”, or “no card”. For offside scenes, there was only one column with the options “offside” or “non-offside”. During the test, participants received no feedback about their decisions. Figure 1 illustrates the procedures of the experimental situation.

The reproduction of task conditions within lab conditions searches for task representativeness. Therefore, previous studies (Catteeuw et al., 2009; Schweizer, Plessner, Kahlert, & Brand, 2011; Spitz et al., 2016) have proposed that video scenes should have a visualization time between 1000 and 2000 milliseconds (ms), which is the time needed for decision making within a game context (Hillstrom, 2000; Nodine, Mello-Thoms, Kundel, & Weinstein, 2002). However, due to the task characteristics in this study, a longer duration of the scenes (up to thirty-five seconds) was adopted, allowing the referees to understand the context in which the decision is taken.

Figure 1. Decision-making assessment protocol

Dependent variables

The data recorded by the Eye Tracking equipment were analyzed using the software Be Gaze 3.5.7.4. The number of gaze fixations was calculated as the number of times the participant fixed his/her gaze within a visual angle of 3° for a time interval ≥ 100 ms, as suggested by Panchuk & Vickers, (2006). The duration of gaze fixations was calculated as the mean duration of all fixations performed by the participant (Roca, Ford, McRobert, & Williams, 2011).

The quality of decision making was based on the answers given to the question “What decision should be made” after each game scene. The answers were compared to the ones provided by FIFA on their website www.labhipermedia.net/downloads/category/downloads-english/. For the correct and incorrect decisions, participants received 1 and 0 points, respectively. Foul situations (15) included two answers and out-of-bounds situations (6) included one answer, totaling 36 answers per participant. The participants’ score was given by the number of correct answers (maximal score 36 points).

Statistical analyses

Descriptive analyses of the dependent variables were made by calculating the mean and standard deviation. The Shapiro-Wilk test and Levene’s test were used to identify possible deviations to normality and homoscedasticity, respectively. After parametric assumptions, the independent t-test was used to compare the means between groups (national vs. state-level). Cohen’s d effect size was calculated for each variable and classified as small (0.2), medium (0.5), or large (0.8) (Cohen, 1988).

Statistical significance was set at 5% ($p < .05$) for all the analyses. All the statistical analyses were performed using the SPSS Statistics software (version 20; SPSS, Inc., Chicago, IL, USA), except for effect size, which was calculated using the software G.Power (version 3. 0. 10; Inc., UCLA, USA).

Results

The results are shown in Table 2. There was no significant difference in decision making and the number of gaze fixations between groups G1 (national) and G2 (state). However, G1 presented a shorter gaze fixation compared to G2.

Table 2. Means and standard deviation of the number of correct decisions, the duration of gaze fixations, and the number of gaze fixations in national and state-level referees.

Variables/Groups	G1 (National)	G2 (State)	<i>p</i> -value	Effect size
Number of correct decisions (n)	30.6 (2.3)	29.0 (2.5)	.146	0.666
Duration of visual fixations (ms)	4044 (1565)	213 (85)	.003*	3.456
Number of visual fixations (n)	1404 (544)	1408 (683)	0.359	0.006

* - Significant difference, $p < .05$.

Discussion

This study aimed to compare the gaze behavior and decision making between national-level and state-level soccer referees. Results showed that national-level referees had shorter gaze fixations, despite the lack of differences in the number of gaze fixations and quality of decision making. These results suggest that national-level referees can extract relevant information (relevant cues) from the environment more efficiently than state-level referees.

Gaze behavior is related to the cognitive processes underlying decision making in sport (Bar-eli & Raab, 2006). The differences in this study for the duration of fixations between groups do not corroborate previous findings (Catteeuw et al., 2009; Hancock & Ste-Marie, 2013; Spitz et al., 2016), and suggests a higher cognitive skill in national-level Brazilian referees in comparison to the state-level ones. This higher cognitive ability is mainly explained by their ability for identifying and directing their attention to the most relevant cues in the environment and make correct decisions within a shorter time frame (Ericsson & Kintsch, 1995; Roca et al, 2011). In this context, the recognition of situation patterns within a time-constrained context, allow higher-level referees to be more efficient for decision making.

Similar to previous studies (Catteeuw et al., 2009; Spitz et al., 2016), the results of the present study indicated no difference between national and state-level referees for the number of gaze fixations. Other research suggests that the differences in the gaze behavior between referees of different levels (national and international) are based on the quality of information extraction through peripheral vision (Catteeuw et al., 2009; Hancock & Ste-Marie, 2013). In those studies, the authors suggested that higher level referees can expand their peripheral vision to correctly interpret the situation. Conversely, our results indicate differences in the central vision (duration). These data suggest that differences between national and international referees are not only explained by characteristics of the central or peripheral vision, but both variables may play an important role. From a practical perspective, the results of the present study suggest the need to include perceptual training within game situations to develop referees' performance. Also, the assessment of cognitive abilities may be useful in refereeing programs, as a test for referees' progression to higher competitive levels.

The traditional theoretical models for decision making in sport are quite dichotomic regarding the two ways of processing information: top-down- versus bottom-up (Chaiken & Trope, 1999). However, some models, such as the SMART-ER (Situation Model of Anticipated Response-consequences in Tactical decision) (Raab, 2015) propose that both ways contribute to the perception in sport, although one of them will prevail according to the characteristics of the task. In this study, the relatively long time available to perform the tasks (35 seconds videos with different angles of view) suggests that decision making is supported by deliberative processes, with a great contribution of the top-down way information processing. For this reason, we hypothesize that Brazilian referees from national and state-level present similar structural basis of knowledge about the task contents, leading to a lack of difference between them for decision making. Therefore, although the lower level referees had longer gaze fixations, the longtime available to analyze the game situation allowed them to extract the relevant information and make correct decisions, which is supported by the longer fixation duration reported by the most expert referees in the current study. Future studies should use different conditions of time constraints to investigate the perception and decision-making phenomena in soccer referees in game situations. This knowledge will be useful in guiding refereeing programs.

The participants of the present study included central and assistant referees. Due to the differences in their role within the game and their different angles of vision, future studies should investigate whether they present differences in their gaze behavior. This knowledge can provide important information for structuring refereeing programs. Besides, investigations with more realistic settings (field tests), qualitative analysis regarding the relevant cues perceived by referees, and videos of the game situations from different views may also provide a deeper understanding of referees' perceptual and decision-making processes, supporting the development of refereeing performance.

Conclusions

We conclude that national-level soccer referees are more efficient at extracting relevant information for decision making in foul and out-of-bound situations compared to state-level referees, despite no differences in the quality of decision making. The higher efficiency found in higher-level referees is evidenced by their shorter gaze fixations, which suggests they can perceive situation patterns more quickly.

Conflicts of interest

The authors have no conflicts of interest to declare.

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