Visual search strategy and anticipation in tactical behavior of young soccer players

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ABSTRACT
The aim of the present study was to compare the visual search strategy (VSS) and anticipation between two groups of young soccer players of different efficiencies in tactical behavior (TB). A total of 44 Brazilian male soccer players aged 14.00 (± 1.06) years from three regional clubs participated in the study. TB was assessed using FUT-SAT; anticipation score was obtained by a video-based assessment, while VSS was performed using the Mobile Eye-XG® system. The soccer players were divided into two groups based on their TB results into those more efficient and those less efficient. The results showed that soccer players with higher efficiency in TB were better at anticipating and performed a higher number of shorter visual fixations and a greater average amount of fixations per location. They were also able to adjust their VSS in performing a longer fixation time on the player in possession of the ball. Therefore, there is support for an integration of visual search strategy and anticipation within tactical behavior. Visual search strategy and anticipation seem to contribute to the efficiency of tactical behavior in young soccer players.

Introduction
Anticipation reflects the ability to predict a probable event even before it occurs (Williams 2002; Williams et al. 2017). For example, in soccer anticipation is essential in situations where players need to process information under time pressure to formulate and execute an appropriate response in an unpredictable and complex environment (Williams et al. 2011; Roca and Williams 2016; Williams and Jackson 2019). This need for the correct response demands strong cognitive and tactical abilities, in addition to technical and physical competencies (Williams et al. 2004; Roca et al. 2012).

Researchers have developed studies in an attempt to identify the competencies which underpin anticipation judgments in soccer players in order to understand the processes and mechanisms underlying anticipation and the way it impacts soccer player’s performance (Ward and Williams 2003; North et al. 2009; Roca et al. 2011; Causer et al. 2017). For example, Ward and Williams (2003) found that skilled young soccer players were better at anticipating actions in the game during different situations compared to less skilled soccer players. North and colleagues (2009) also found similar results when comparing elite and amateur soccer players. Adding to these results, Causer and colleagues (2017) highlighted the stronger ability of expert soccer players to gather visual information and anticipate the play. Thereby, anticipation judgments are at least partly based on the amount of perceived visual stimuli and by their interaction with perceptual-cognitive skills (North et al. 2011).

Accordingly, a high anticipation capacity presupposes the integration of perceptual-cognitive skills (Williams et al. 2009, 2017; Roca and Williams 2016). For example, expert soccer players are better at evaluating situational probabilities of action in specific moments of the game (Ward and Williams 2003; Belling et al. 2015), and are also more accurate in recognizing patterns (North et al. 2011, 2016) and identifying postural cues (Savelsbergh et al. 2005; Wright et al. 2014; Causer et al. 2017). These characteristics also reflect the expertise of performing players in detecting information in the game environment through the efficient use of visual search strategy (Williams et al. 2004; Roca et al. 2013).

Thus, although anticipation depends on the interaction of perceptual-cognitive skills (Roca and Williams 2016; Williams et al. 2017), studies have investigated how visual search strategy support anticipation judgments (Williams et al. 1994; Roca et al. 2011; Casanova et al. 2013; Causer and Williams 2015; Vater et al. 2016). As an example, studies using video scenes have shown that elite and expert soccer players in open game situations (e.g. 5 vs. 5 or 11 vs. 11) use visual search strategies with a higher number of shorter fixations than beginners and amateurs (Williams et al. 2006; Vaeyens et al. 2007; North et al. 2011). On the other hand, the visual behavior of experts in closed game situations (e.g. 1 vs. 1) featured a higher number of visual fixations of longer duration than novice players (Roca et al. 2011, 2012). Therefore, visual search strategy has specific characteristics according to the context and task demands (Williams et al. 2004; Huys et al. 2009; Runswick et al. 2018).

Studies which have aimed to understand and compare visual search strategy and anticipation between soccer players, have usually sought to identify and analyze them by sampling predetermined groups of players based on contextual variables including competitive levels (Roca et al. 2011; Williams et al. 2012), age levels (Ward and Williams 2003; Machado et al. 2011).

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2017), and experience (North et al. 2009; Vater et al. 2016). However, these contextual variables are already a determinant in performance by themselves, since these players are playing in different competitive levels (for a review, see Voss et al. 2010). Thus, it is difficult to understand the actual implication of the role of visual search strategy and anticipation in the tactical performance of young soccer players.

Therefore, it is necessary to take into account the separation of groups by tactical behavior when assessing anticipation and visual search strategy. Such a separation of groups by characteristics of tactical behavior helps reducing the subjectivity of choice of groups of soccer players from different levels. In fact, tactical behavior reflects the relevancy of the execution of actions within temporal and spatial constraints experimented throughout the complexity of the game (Teoldo et al. 2017). In such context, there is a natural interaction between perceptual-cognitive and motor skills for players to present certain tactical behavior (Gréhaigne et al. 2001; Williams and Ericsson 2007). Therefore the cognitive aspects are embedded in each tactical behavior underlying the movements and positioning of the players (Blomqvist et al. 2005).

Thus, we used the specific FUT-SAT field test to assess young soccer players’ tactical behavior in this study (Teoldo et al. 2011) to create two groups of players: a tactically more efficient and less efficient group. The FUT-SAT was chosen for being an instrument which enables evaluating the information related to managing the game space with more specificity and objectivity than other instruments in the literature (Teoldo et al. 2017). This instrument has its conceptual structure based on the fundamental principles of the game of soccer, which are rules about the game that allow players to solve the problem situations that arise in games (Teoldo et al. 2011). We subsequently compared the performance of the two groups in the anticipation test and in the visual search strategy, aiming to compare the effect of anticipation and visual search strategy on tactical behavior. Based on previous studies in this specific area, our hypothesis was that there would be an interaction between cognitive skills and the application of the tactical component through better management of the playing space (Blomqvist et al. 2005; Williams et al. 2011; Machado et al. 2017; Teoldo et al. 2017). Thus, more tactically efficient soccer players would show a unique visual search strategy and superior anticipation.

Materials and methods

Participants

A total of 44 Brazilian male soccer players from three regional clubs participated in the study. Soccer players were 14.00 (± 1.06) years of age and their average practice time in soccer was 5.12 (± 2.70) years. Inclusion criteria required that all players had participated in structured training sessions lasting at least 1 hour and 30 min, three times a week, participated in regional competitions, and did not have any eye/vision problems.

The legal guardians of the adolescents provided informed consent to allow participation in the study. All procedures were conducted according to the National Health Council Resolution (466/2012) and the Helsinki Ethics Treatment for research with human beings. The research was approved by the Research Ethics Committee of the Universidade Federal de Viçosa, number 43585115.1.0000.5153.

Apparatus and Procedure

Tactical Behavior

A recognized Soccer Tactical Assessment System (FUT-SAT) was used to assess the efficiency of tactical behavior (Teoldo et al. 2011). The FUT-SAT enables evaluating the effective tactical behavior of players by analyzing their tactical actions with and without possession of the ball. FUT-SAT is based on core tactical principles of soccer, taking into account five principles for the offensive phase and five for the defensive phase (for a review, see Teoldo et al. 2017).

The field test which composes this instrument was performed in a field of 36 × 27 meters. The FUT-SAT was applied at the players’ own training locations in their clubs. Participants were grouped into teams of three soccer players and one goalkeeper (GK + 3 vs. 3 + GK). The soccer players were randomly selected to compose the teams for the test according to the positional roles (defenders, midfielders and forwards) they fulfill when playing for their own team. The goalkeepers were not evaluated, as their actions differ from those of other soccer players. The players played according to official soccer rules during the test. They were given 30 seconds for familiarization prior to the application. The test had a total duration of 4 minutes as recommended in the original protocol (Teoldo et al. 2011). It was filmed using a SONY® HDR-XR100 digital camera capturing at 25 fps. The video scenes were digitally transferred to a laptop computer (DELL® Inspiron N4030 Intel Core™ i3 processor) via USB cable and converted to an ‘.avi’ file by Prism Video Converter Inc® software. Soccer Analyzer® software was used for video processing and data analysis.

The efficiency of tactical behavior performed by the young soccer players was used to measure the tactical behavior. The percentage of correct tactical actions was calculated by the ratio between the percentage of correct tactical actions and the total number of tactical actions performed (for a review, see Teoldo et al. 2011). Values regarding TB were presented in percentages ranging from 0% to 100%.

Anticipation

The participant’s performed the anticipation test the day after the tactical behavior test. The test was performed with two participants at a time, randomly selected, sitting side-by-side in a controlled lab. Video test protocol was used to assess anticipation (Larkin et al. 2015; O’Connor et al. 2016). This video test protocol consisted of 20 video-clips of elite level offensive soccer sequences (11 vs. 11 matches). Each video-clip lasted between 5 to 10 seconds and the video clips were presented in a third-person perspective with an in-depth viewing angle (for a review, see Larkin et al. 2015). The video-clips were presented and occluded 120 milliseconds before the player in possession of the ball would perform a technical action with the ball. Participants were instructed to watch video clips and anticipate what would be the technical action
and in what direction the technical action would occur. The options were: a) pass; b) dribble; or c) finish (strike on goal). This procedure followed protocols proposed by the authors (Ward and Williams 2003; Roca et al. 2011; Machado et al. 2017).

The last frame image of each video clip was presented to participants by an Apple iPad®, iOS version 8.2 (12D508). The last frame image on the Apple iPad® was presented through the Xodo® app, in which the participants were asked to indicate the technical action of the player in possession of the ball by writing a letter initial: P – pass, D – dribble and F – finish (strike on goal); and by drawing an arrow pointing the direction of the chosen action. If the option was a pass, the participant should have circled the player who the ball would be sent to. Participants then confirmed their answer and moved on to the next image. They could only respond after watching the video clip scene. Both the letter and arrow were subsequently checked and evaluated according to the best response indicated in the protocol (for a review, see O’Connor et al. 2016). Each video clip was assigned a two-point maximum total for the anticipation test score: one point for the correct technical action, and one point for the correct direction. Participants had a five-second break to respond between each scene. The anticipation test score values were converted to a percentage ranging from 0% to 100%.

The experimental video procedure was performed indoors without external interference and controlled brightness with a maximum variation of 07 lux. The video clip scenes were projected by an HD projector (Toshiba® TDP-s20 DLP A, Texas) with an XGA resolution of 2.50 m x 2.00 m. The participants were positioned three meters from the screen and seated with a clear view of the screen. Players were introduced to three practical video clip scenes prior to the test for familiarization purposes.

**Visual search strategy data**

The Mobile Eye Tracking-XG® was installed on the participants during the anticipation test. Mobile Eye Tracking-XG® is an instrument used to assess a subject’s visual search by tracking their central gaze. It has a camera system mounted on a pair of glasses that detects the movement of pupil and corneal reflection (Duchowski 2007). After controlling the ambient light, the Mobile Eye Tracking-XG® was adjusted and the calibration procedure was performed with the participants. The equipment calibration was periodically checked at the end of each video sequence to ensure accuracy. The entire test application procedure lasted approximately 20 minutes for each participant. The following measures were analyzed: visual search rate and fixation location.

**Visual search rate:** The visual search rate analysis was performed following previous research procedures (Williams and Davids 1998; Roca et al. 2011; Machado et al. 2017). The following dependent variables were assessed for statistical analysis: (i) Number of fixations; (ii) Fixation time (in milliseconds); and (iii) Mean of fixations per location. Each fixation was defined as the condition in which the eye remained stationary at approximately 1.50 degrees of variation tolerance and for a period equal to or greater than 120 ms or three video frames.

**Fixation Location:** Fixation location refers to the percentage of fixation time employed by the participant evaluated at predefined locations in the scenes. Six specific locations were predefined for analysis in the present study: (i) player in possession of the ball; (ii) ball (ball trajectory); (iii) teammates; iv) opponents; v) space (areas of free space on the field where no player is located); and vi) others (none of the previously-listed places) (Roca et al. 2011; Machado et al. 2017).

**Data Analysis**

**Tactical behavior**

The participants were then classified into two groups according to the values obtained using the FUT-SAT and characterizing those who presented the best and worst performances on the test. The more efficient group (n = 22) included players who scored ≥50%, while the less efficient group (n = 22) included those whose score was ≤50%. A descriptive analysis (mean, standard deviation and percentile) was used to obtain information about the sample. Data distribution was analyzed using the Kolmogorov-Smirnov test, which indicated a non-normal distribution. The Mann-Whitney test was used to compare the percentage of correct tactical actions between the ‘less efficient’ and ‘more efficient’ groups (z = −5.681; p < 0.001; d = 7.12), indicating a statistical difference between groups (see Table 1). The effect size is reported using Cohen’s d, with the reference values being: below 0.19 for insignificant values; between 0.20 and 0.49 for low; between 0.50 and 0.79 for intermediate; between 0.80 and 1.29 for high; and above 1.30 for very high values (Cohen 1988).

The data reliability analysis was performed by five evaluators (Robinson and O’Donoghue 2007). The Kappa Cohen test was used and a value of 13% of the tactical actions was re-evaluated, indicating a higher value (10%) than indicated in the literature (Tabachnick and Fidell 2007). Intra-rater reliability values ranged from 0.818 (se = 0.054) to 1.000 (se = <0.001); and 0.828 (se = 0.065) and 1.000 (se = <0.001) for inter-rater reliability.

**Anticipation**

Data distribution was analyzed using the Kolmogorov-Smirnov test and indicated a non-normal distribution. The Mann-Whitney test was performed to compare the groups. The effect size was reported using Cohen’s d (Cohen 1988).

**Visual search strategy data**

**Visual search rate:** The visual search rate data distribution was analyzed by the Kolmogorov-Smirnov test, which indicated a normal distribution. The t-test for independent samples was used to compare groups in relation to the dependent variables.

**Fixation location:** Factorial two-way ANOVA by Group (more efficient and less efficient) was used as the between-participant factor and Fixation Location as within-participant factor.

| Table 1. Descriptive and inferential values of tactical behavior. |
|-------------------------|-----------------|-----------------|---|
| **Tactical Behavior** | **Less efficient** | **More efficient** | **p** |
| Percentage of correct tactical actions | 71.91 ± 3.20 | 91.08 ± 2.06* | <0.001 |
| Practice time in soccer (years) | 5.23 ± 2.60 | 5.32 ± 2.65 | 0.922 |

* Significance level p < 0.05; SD = standard deviation.
factor to analyze the percentage viewing time. The Greenhouse–Geisser correction was employed for cases in violation of Mauchly’s sphericity test. Bonferroni post hoc tests were performed to verify significant differences. The effect size was calculated using partial eta (ηp^2), with the reference values being: < 0.05 for low values; between 0.06 and 0.13 for intermediate; and above 0.14 for high (Cohen 1988). Initial fixation values were examined and inter and intra reliability values calculated (91% for intra-rater reliability and 83.9% for inter-rater reliability).

**Results**

The mean and standard deviation values for anticipation test score and visual search rate are presented in Table 2.

### Anticipation

Results of the anticipation indicated a significant difference between the groups (z = −2.640; p = 0.008; d = 0.75) for which the more efficient soccer players presented better results.

### Visual search strategy data

**Visual search rate:** The results showed significant differences in the visual search rate between the groups. The more efficient soccer players performed the highest number of fixations (t (42) = 3.745; p = 0.001; d = 1.13) of shorter fixation time (t (42) = −2.062; p = 0.045; d = 0.62), and a higher average amount of fixations per location (t (42) = 3.746; p = 0.001; d = 1.13).

**Fixation location:** Significant main effects for fixation location (F (5,210) = 199.91, p < 0.001, ηp^2 = 0.81). Pairwise comparisons of all participants demonstrated more time fixating on the player in possession of the ball (50.95 ± 11.96%) in comparison to any other location (p < 0.001). The participants presented higher fixations on teammates (16.08 ± 6.70%) in comparison to ball (9.64 ± 5.90%) (p = 0.003), space (7.40 ± 5.70%) and others (4.95 ± 5.54%) (p < 0.001). They also spent more time fixating on opponents (10.99 ± 5.47%) in comparison with others (4.95 ± 5.54%) (p = 0.008).

Factorial ANOVA showed a significant Group x Fixation Location interaction (F (5, 210) = 5.51, p = 0.004, ηp^2 = 0.02). The results are illustrated in Figure 1. A post hoc test showed

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**Table 2.** Descriptive and inferential values of anticipation and visual search rate.

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<tr>
<th></th>
<th>Less efficient</th>
<th>More efficient</th>
<th>p</th>
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<tbody>
<tr>
<td><strong>Anticipation</strong></td>
<td></td>
<td></td>
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<tr>
<td>% Anticipation total score</td>
<td>66.93 ± 12.93</td>
<td>74.77 ± 7.03*</td>
<td>0.008</td>
</tr>
<tr>
<td><strong>Visual Search Rate</strong></td>
<td></td>
<td></td>
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<tr>
<td>Number of fixations</td>
<td>8.44 ± 2.59</td>
<td>11.05 ± 2.00*</td>
<td>0.001</td>
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<tr>
<td>Fixation time</td>
<td>760 ± 202.18</td>
<td>635.77 ± 197.35*</td>
<td>0.045</td>
</tr>
<tr>
<td>Mean of fixations per location</td>
<td>28.11 ± 8.65</td>
<td>36.85 ± 6.68*</td>
<td>0.001</td>
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</table>

* Significance level adopted p < 0.05; SD = standard deviation.

**Figure 1.** Percentage of fixation time at different screen fixation location.
that more efficient soccer players spent more time fixating on the player in possession of the ball compared with tactically less efficient players (55.96 ± 9.32% vs. 45.93 ± 14.59%, p < 0.001, d = 0.82).

**Discussion**

The aim of this study was to compare the anticipation and visual search strategy between two groups of young soccer players with different tactical behaviors. The results confirmed the hypothesis in which there seems to be an interaction between cognitive skills such as anticipation and visual search strategy with the application of tactical behavior by soccer players. The more tactically efficient soccer players showed a different visual search strategy and better anticipation judgments. The results presented a moderate and high effect size, enabling to conclude that the more tactically efficient soccer players are better at anticipating actions of teammates and opponents.

Correspondingly, the more efficient soccer players performed the largest number of short fixations. This behavior is similar to that of elite soccer players and experts in open game situations (e.g. 5 vs 5, 11 vs 11) (Williams et al. 1994; Vaeyens et al. 2007). Thus, this strategy enables more efficient players to map their action possibilities better and more quickly, and to extract more information in a shorter period in order to prepare a response in advance (Williams and Davids 1998; Williams and Ward 2007; Williams et al. 2009).

Tactically efficient soccer players performed a greater average amount of fixations per location. Thus, they were able to broadly focus their attention to seek and process relevant information in a shorter time. Although our research did not involve expert groups or novices, but young soccer players, the more efficient soccer players seemed to be able to adjust their focus and search for relevant information at crucial moments such as involved players near the game center, rather than less representative stimuli (Williams et al. 2009; Williams and Jackson 2019).

In this case, the representative information came from players involved in the game center. The game center is a virtual circle with a five-meter radius from the game epicenter and moved according to where the ball is (Teoldo et al. 2011). Thus, the more efficient players performed the longest fixation time gaze on the player in possession of the ball. Therefore, action location and contextual information of the task are essential stimuli to enable better anticipation judgments (Roca and Williams 2016; Runswick et al. 2018). Our study reinforces the idea that the more efficient soccer players use contextual and kinematic sources of information during early judgments (Runswick et al. 2018). Thus, by observing task-specific actions, the more tactically efficient soccer players can possibly recognize patterns and construct situational probabilities based on the interaction of visual perception, working memory, and attention to anticipate possible actions according to task context (Williams et al. 2004; Roca et al. 2013; Roca and Williams 2016). Hence, they minimize uncertainty by creating scenarios of possible anticipation events and assigning expected action-based probability hierarchies (Williams and Jackson 2019).

Therefore, we can suggest that the more tactically efficient soccer players are provided with an efficient neural structure which is able to modulate the use of working memory for given contexts and tasks. One hypothesis for this finding is that there is considerable working memory activation and greater central executive activity in self-controlled motor tasks (Jaquess et al. 2019). Then, the more tactically efficient players could make better anticipation judgments with the specific application of visual search strategy, possibly requiring less cognitive effort (Vickers and Williams 2017; Cardoso et al. 2019).

On the other hand, the less tactically efficient soccer players had fewer visual fixations of a longer duration. This strategy does not seem to be advantageous according to the variety of stimuli involved in the task, as it could make it difficult to read crucial information (Huys et al. 2009; Williams et al. 2009; Roca et al. 2011).

Therefore, we believe that the efficiency of tactical behavior is a result of the ability of soccer players to better utilize their perceptual and cognitive processing structure and properly employ visual search strategy in anticipating the actions of teammates and opponents. In particular, these results have shown that understanding the position and location of players near the game center enables players to better anticipate the actions. Hence, tactically efficient soccer players benefit from their cognitive efficiency in seeking crucial sources of information for anticipation judgments. This gives the more efficient players a clear and competitive advantage in formulating appropriate tactical responses to respond appropriately and with greater assertiveness to game situations (North et al. 2009; Roca et al. 2011; Williams et al. 2011).

It should be noted that this study is, a priori, the first to assess anticipation and visual search strategy featuring a separation of players according to their tactical performance. Despite the advances of this study, one of its limitations concerns the use of cognitive tests with little ecological validity. Although commonly used in the literature (Vaeyens et al. 2007; Roca et al. 2011, 2012; O’Connor et al. 2016) and allowing researchers to extrapolate data, these tests do not simulate real game environments or their physical, tactical, technical and cognitive requirements. We suggest that further research be conducted to investigate the association between tactical components, visual search strategy and anticipation in game and competition-like environments. As an example, research which recreates appropriate levels of emotional and physical stressors such as anxiety, mental and physical fatigue would be more representative of the reality of the play.

**Conclusion**

In conclusion, the more tactically efficient young soccer players were better at anticipation judgments and employed a different visual search strategy compared to their less efficient teammates. The more tactically efficient soccer players presented a higher number of short visual fixations, demonstrating a broader attentional focus in searching and processing advantageous information in less time. They were also better able to adjust their visual search strategy to focus on relevant information near the game center, such as the player’s displacements in...
possession of the ball. Thus, more efficient soccer players appear to have better perceptual structure and cognitive processing during anticipation judgments. This could provide a competitive advantage in formulating appropriate responses to the game situation, contributing to greater tactical behavior efficiency. Therefore, there is support for an integration of visual search strategy and anticipation with tactical behavior in which visual search strategy and anticipation seem to contribute to the efficiency of tactical behavior in young soccer players.

Practical implications

- This study provides important information for coaches and teachers to realize that the effectiveness of tactical behavior displayed by soccer players is associated with how these players employ their visual search strategy during anticipation judgments.
- The assessment of tactical behavior through the field test, such as the application of the FUT-SAT instrument, seems to be a reliable and accessible alternative for clubs and academies, as it presents results with a close relationship to cognitive skills such as anticipation and visual search.
- From this perspective, coaches must create training situations which involve visual stimuli and reading specific game situations after assessing tactical behavior with the aim to improve anticipation in the game itself and consequently to improve the efficiency in tactical behavior.

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Disclosure statement

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