

Original article (short paper)

What mental process favours quality decision-making in young soccer players?

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Abstract — Aim: The aim of this research is to identify the mechanisms that lead soccer players to make quality tactical decisions, and how these mechanisms evolve over time. **Methods:** Ninety male youth players training in a professional club in Brazil were submitted to a soccer video test which consists in making tactical decisions when the image freezes. These participants were divided in five groups with 18 players in each of following age levels: Under-11, Under-13, Under-15, Under-17 and Under-20. The dominant statements of verbal reports were distributed in categories that reflect key mechanisms. The frequency of correct tactical answers was calculated for each statement types and Standard Residuals (e) were calculated to verify the influence of the mechanisms on the quality of tactical decision for each age level. **Results:** Results revealed that evaluation statement was related to accurate tactical decisions from Under-15 age level. **Conclusion:** In conclusion, evaluation of perceived information makes better decision makers.

Keywords: cognition, decision-making, development.

Introduction

The role of cognition in the decision-making process has long been studied, especially to identify the characteristics of experts performance in various disciplines. Important contributions in this area achieved to identify key mental resources to decision-making such as memory and perception¹. Although, scarce findings offer a complete understanding of how these resources are used during decision-making in sports. Classical scientific approaches on expertise in various domains present difficulties to seize how decisions are made in collective sports due to specific game constraints². Although, decision-making in sports remains of particular interest due to the manifestation of the cognitive activity in the instantaneous actions during the game, as it is the case for soccer.

Studies in this area have focused on the mental processes that allow a player to momentarily generate a relevant action in a given game situation, for instance, to progress towards the opponent's goal or to maintain the possession of the ball. This decision refers to a tactical action and requires a player to appeal to cognition at each moment of the game to process the perceived information and generate a decision to execute. Thus, actual investigation in this area seeks to determine what process allows experts to make quality decisions. In the present study, we focused on the mental processes that referred to cognitive

mechanisms. Four of them have been identified in performing athletes: monitoring (describe the situation), evaluation (assess), prediction (anticipate) and planning (prepare)³. Although, limited literature offers systematic investigation of the mechanisms leading to quality decision-making in team sports.

In general, such investigations are pursued in laboratories. Verbal reports are used as data to identify the cognitive processes used to make a decision^{4,5}. Vaeyens and his collaborators⁶ have shown that experts' capability to consider key information and to generate appropriate tactical actions reflects analytical and goal-oriented decision-making qualities. Although, further studies must be realized to identify which mechanism favours quality tactical decisions. One avenue consists in analyzing how tactical decisions are verbalized because the words reflect the mechanisms used to process information⁷.

On another hand, studies also show that players gain experience and knowledge through training and competition^{8,9}. This has led to a plethora of studies on expertise^{10,11}. Nevertheless, there's a clear interest in assessing youth players in their progression to elite level. This includes understanding how their mental processes evolve as they are going through their development phase. Previous studies of maturation show obvious transformation in players' adolescence, counting with remarkable cognitive evolution as long as these capabilities are solicited and trained^{12,13}. Hence, it is suggested that mental processes should

evolve through maturation. In that case, scientific methods can be used to identify how players process information, and trace their cognitive progress over time.

Given the previous arguments, the aim of this research is to identify the mechanisms that lead players to make quality tactical decisions, and how these mechanisms evolve over time. We hypothesize that the mechanisms are likely to influence the quality of tactical decisions as the players undergo formal training during their development phase. Plus, mechanisms should change through age levels considering the biologic maturation process during adolescence. This research is expected to offer more understanding of the progression of mental processes during the formative years.

Methods

Participants

The sample was composed of 90 male soccer players of the training teams of a Soccer Club affiliated to the Soccer Federation of the State of Rio de Janeiro, in Brazil, and to the Brazilian Soccer Confederation. These participants were divided in five groups with 18 players in each of the age levels presented in the Table 1. All participants did provide the amount of years they have been practicing soccer, as they fulfilled the questionnaire of characterization. A rounded estimation was calculated in respect with the amount of years and an average of 32 hours per month, suggested by the club, in order to compile the total of hours of general practice of soccer. Also, the archives of the club were consulted to retrieve the date of arrival of each participant. The same estimated training time was calculated according to the date of arrival in order to compile the hours of formal practice in the club.

The present work was submitted and approved by the Committee of Ethics in Researches with Human Beings of the Federal University of Viçosa (CEPH: 403.759), and follows the norms established by the resolution of the National Council in Health (CNS: 466/2012) and by the Treat of Ethics of Helsinki (1996) on researches with human beings. The directors of the club signed a document authorizing the realization of the data collection, the usage of the club's infrastructures and the participation of the player to the research activities. The legal tutors of each players signed an informed assent form before the realization of the tests, allowing the participation of the players to the study and the usage of the data for research purposes.

Data collection procedures

Tactical Decisions

A tactical test was used in this study to estimate players' game knowledge. According to the original test protocol^{14,15,16}, this methodology uses 11 offensive soccer scenarios (11 vs. 11) to assess their tactical decision in each action. The visioning

was realized in quiet conditions with controlled light, using a projector to display the video sequences on the wall. The scenarios was presented to each participant, where an image was frozen for two seconds before the player decided «what to do». He was given the time he needed to give his answer and justify his decision. A point was given if the solution matched the best option unanimously determined by four experts during the test construction. Two experts validated the participants' answers to ensure they matched the original code. The participants were able to familiarize with the procedure before the test began as they were given two practice trials.

Verbal reports

The answers of the test previously mentioned were recorded and analyzed according to the adaptation of the Protocol of Verbal Report⁴ elaborated by Ward and his collaborators³. This adaptation was used in a study similar to ours and was described by the authors as follows¹⁷. There are four main categories of statements: (a) monitoring statements, described as the recalls to current actions or descriptions of current events; (b) evaluations, described as some form of comparison, assessment, or appraisal of events that are situation-, task-, or context-relevant; (c) predictions, described as anticipation or highlights of future or potential future events; and (d) planning statements, described as the decision (s) on a course of action in order to anticipate an outcome or potential outcome of an event. During the analysis of the verbatim, each scene was ascribed the dominant statement type amongst the ones listed above. The frequency of each dominant statement type was compiled.

Statistical Analysis

All the statistical procedures were performed on SPSS (Statistical Package for Social Science) for Windows®, version 20.0. The frequencies of correct answers were calculated per statement type per age level, which allowed to observe how many correct tactical decisions were associated with each statement type. Also, in order to comprehend the strength of the influence of each statement type on the amount of correct answers in all age levels, the Standard Residuals (e) were calculated using the following formula¹⁸, where N is the amount of correct answers. A significance level of $e < 1.96$ ($p < 0.05$) was adopted.

Standardized Residuals (e) = $(\text{observed } n - \text{expected } n) / \sqrt{\text{Expected } n}$

Results

Table 2 shows the frequencies of correct answers (C.A.) per statement type for each age level, as well as the standard residuals (e). At first, significantly higher amounts of correct answers were found for monitoring statements in the youngest age level, for evaluation statements in age levels from Under-15

to Under-20, and for prediction in Under-15 age level. It also can be observed that prediction statements show significantly

low amounts of correct answers in all age levels. Standardized residuals for these corresponding categories are significant.

Table 1. Mean ± standard deviation (SD) of age and hours of practice for each age level.

Age level	Age (years)	Hours of general practice	Hours of formal practice with the club since day of arrival
Under-11	9.86±0.24	1685.33±647.11	554.67±133.47
Under-13	12.87±0.21	2624.00±607.16	693.33±337.23
Under-15	14.89±0.25	2880.00±712.34	1409.78±756.69
Under-17	17.00±0.24	3520.00±1080.11	1703.00±1175.52
Under-20	18.57±0.95	N/M	2516.22±1896.79

Note: N/M = Not measured.



Figure 1. An example of frozen image of a video sequence (Adapted from Mangas et al., 2002).

Table 2. Frequency of correct answers (C.A.) and standardized residuals (e) per statement type for each age level

Statement	Under-11		Under-13		Under-15		Under-17		Under-20	
	C.A.	e	C.A.	e	C.A.	e	C.A.	e	C.A.	e
Monitoring	34	1.97	32	0.50	14	-3.16	35	0.12	28	-1.00
Evaluation	29	0.95	38	1.61	50	3.23	57	3.88	47	2.27
Prediction	18	-1.28	30	0.13	44	2.16	31	-0.56	38	0.72
Planning	16	-1.68	17	-2.27	19	-2.27	14	-3.47	22	-2.03

Bold: Frequency of correct answers related to a significantly positive (e > 1,96) or negative (e < -1,96) influence.

The standard residuals (e) showing the strength of influence of the statement types on the amount of correct answers are also outlined in the Figure 2. According to these values, monitoring statement types have been more influent on correct answers in the Under-11 age level, as, in contrast, evaluation is

significantly influent in the Under-15, -17, and -20 age levels. Prediction statements only show significant influence in the 15 years-old group. The negative values of standardized residuals for planning statements demonstrate that such statement had a limiting influence on the amount of correct answers.

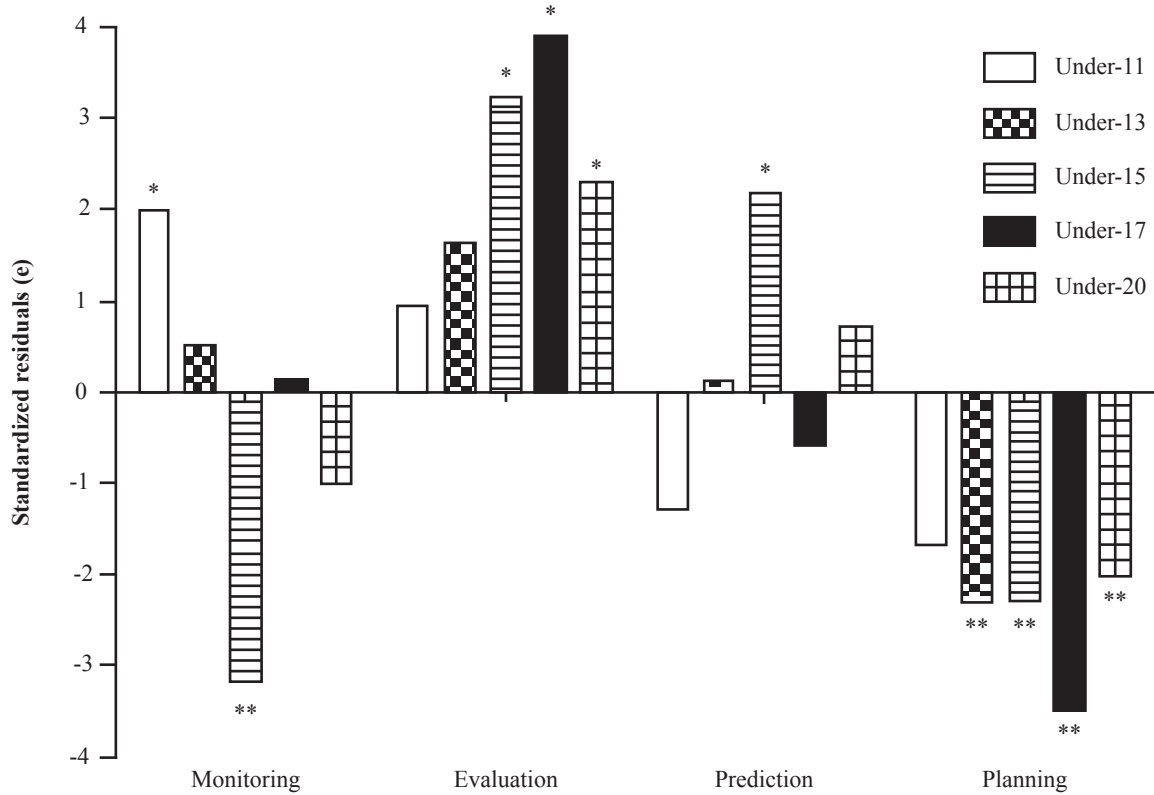


Figure 2. Standardized residuals (e) per statement type for each age level. * Significantly positive influence ($e > 1.96$); ** Significantly negative influence ($e < -1.96$).

An evolution of the influence of the statement type on the amount of correct answers through age levels can be appreciated in two categories: standard residuals are decreasing in the monitoring statements lot and are increasing in the evaluation statements lot. The prediction statements lot does not display any tendency although planning statement lot is regular through all age levels.

Discussion

The aim of this study was to identify the mechanisms that lead players to make quality tactical decisions, and how these evolve through time. The mechanisms were identified recognizing the dominant statement types in verbal reports (monitoring, evaluation, prediction, planning). Results revealed that monitoring was influent on the tactical decisions of younger players and that evaluation statement was related to accurate tactical decisions from Under-15 to Under-20. In contrast, planning statements displayed negative influent relations to the amount of correct answers. To facilitate the discussion, our results will be reviewed in two sections: the first will focus on the influence

of the mechanisms on the quality of tactical decisions and the second will analyze specific changes between age levels.

Influence of the mechanisms on the quality of tactical decisions

From Under-15 age level, evaluation statements were associated to quality decision making. This suggest that the corresponding cognitive mechanisms, that is “comparison, assessment, or appraisal of perceived stimuli”, favours rational tactical decisions¹⁷. According to Ross and his collaborators¹⁹, decision-making is realized through recognition of the elements of the environment. In team sports, these elements can be resumed to the ball, the free space, the teammates and the opponents²⁰. When a player recognizes the configuration of these elements, as referred to configuration of play, he summarily evaluates distances and takes the first option that seems accurate to pursue a determined objective^{21,22}.

In contrast to monitoring statements, evaluation is not limited to notice the situation. Also, prediction and planning relies on evaluation since it represents additional tasks for his cognition²³.

Thus, in comparison to other mechanisms, evaluation can therefore be qualified as the most direct and useful mechanism in the specific decision-making context²⁴. This mechanism leads a player to make a decision because he purposely processes the characteristics of the perceived element in order to direct the generation of a solution. Abundance of correct answers to evaluation statements also supports that the corresponding mechanism is the most favorable to make quality decision.

In contrast, significant negative standard residuals shows that planning statements do not influence the quality of decision-making^{25,26}. As demonstrated by studies on expertise, short term planning is based on an expert's ability to predict and foresee a result of an action he could realize²⁷. The negative relation may be explained by the characteristics of the specific context of invasion games. For instance, a tennis player may have the time to prepare his action (e.g. serve in tennis) while, in contrast, a soccer player does not benefit of such time to prepare any of his actions in the course of the continuous play. In fact, the game constantly updating makes it harder to elaborate a plan that stands². Plus, it must be considered that the majority of the participants could not be considered as experts since they are still training.

Changes between age levels

Results depict a decrease of the influence of monitoring statements and an increase of the influence of evaluation statements through age levels. The monitoring statements are associated with correct answers in the Under-11 age level and the evaluation statements are strongly related to accurate tactical decisions from Under-15 age level (see Table 2 and Figure 2). Essentially, the changes show that participants would monitor less and evaluate more as they progress. This progression can be discussed in three points, that is: i) the maturation of the cognition, ii) the skill and experience of the participants, and iii) the level of difficulty of the competition. These three arguments are in line with the Developmental Ecological Rationality Model since the development of the individual, the task to realize and the context of decision-making are all considered at analyzing the performance of decision-making²⁸.

First, the statement types used in Ward's adaptation of verbal reports protocol reflect the cognitive processes taken in charge by "cool" executive functions. These functions shape the cognitive module that involves "inhibition, working memory, and organizational strategies necessary to prepare a response"^{29,30}. Accordingly, the functions responsible for prospective memory and decision-making origin from the frontal lobe, a brain region that undergoes its major development during childhood and adolescence³¹⁻³⁴. Thus, the development of memory and the capabilities to organize information favours the activation of more proactive mechanisms and helps decision-making³⁵. For instance, the knowledge can be used to anticipate a situation and solve a problem corresponding to a game situation. This would explain the propension of matured players to process perceived information, and shift from monitoring to evaluation.

Second, our results corroborate with the initial research conducted on adults showing that highly skilled players made a

greater amount of evaluation statements when being presented tactical problems³. Also with respect to another study, evaluation statements are highly correlated to expertise qualities such as anticipation and recognition of patterns²⁷. Assuming that older players are more experienced and skilled, these convergences support the rationale these players have a better capacity to store and organize information accumulated over time and retrieve it when needed, as explained by the Long-Term Working Memory Theory³⁶. Since these changes can also be explained by the maturation process and the specific training that the players experiment, the gain of experience also develops the ability to judge the perceived information just as to recognize more from what is perceived.

Finally, the progress to older age levels features competition of greater difficulty, forcing the players to train more in order to stay competitive and make decisions under greater time constraints³⁷⁻³⁹. This pressure shortens the available time to perceive and make decisions and requires players to develop anticipation. Hence, it has been evidenced by Coté, Baker and Abernethy⁹ that specific training time contributes to the development of expertise, knowledge and experience. For instance, this training may explain the increase of prediction statements in the Under-15 players for two reasons⁴⁰: i) such anticipation capabilities are related to a repetitive exposure to organized forms of play that differ from the variants of informal game experienced in Brazil^{41,42}; and ii) formal training offers explicit interventions of the coach and relevant experiences that corresponds to the situations presented in the video test^{43,44}. Therefore, specific and repetitive training and competition increase the probability that participants recognize patterns of video sequences they have been exposed to on a daily basis, and anticipate the course of the play.

Limitations and future research

Some limitations must be considered. It must first be taken in account that decision-making in such context differs from the natural play, forcing the participants to isolate their decisions from the typical motor execution they would normally solicit in the game. Plus, divergent conditions such as reading the game from a first-person perspective, being submitted to time pressure, and different types and dimensions of stimulus could alternate judgement²⁴. The specificity of the "game-reading" task on video may therefore demand cognitive abilities that develop in specific activities such as video visioning or mental practice. Else, since federated and non-federated players have shown different decision patterns in video visioning circumstances earlier, it may be inferred that the mental processes may also develop during specific activities off the field¹⁴.

However, this study shows the following important points. The use of representative decision-making task, that is making tactical decision being shown a video sequence, allows to understand how decision-making works. The study clearly shows that evaluating the situation is a central mental process in making a decision. Furthermore, to the best of our knowledge, this is the first study that distinguished and compared the mental processes that support decision-making between different age

levels in youth soccer (Under-11 to Under-20), and consequently allowed to identify the progression through adolescence, where the biggest part of player training takes place.

Conclusion

It was verified that players go through different cognitive activity as they progress through age levels, that is to monitor less and evaluate more. Such cognitive development allows the players to make more accurate decisions as they undergo formal training. Results appoint evaluation as the most important mechanism for Decision-Making and its efficiency. This study also shows that knowledge and working memory are determining to process information and make quality tactical decision whereas planning may not be as relevant in sports. Finally, this study also suggests that a better capability of evaluation is also necessary to process information under given tactical directives, seize tactical problems to solve and subscribe to a game model⁴⁵. For more representativeness of decision-making in soccer, our results could be verified with an interpretative research using retrospective verbal reports of actual actions in the game⁴⁶.

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