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Article

Effects of self-regulatory processes on cognitive representation of team-specific tactics in junior male soccer players

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Abstract – The present study aims to demonstrate the relationship between cognitive and behavioral variables that configure expert performance by testing if training in self-regulatory processes would affect the organization of tactics mental representation in soccer. A 2×2 mixed design was applied, manipulating the level of training in self-regulatory processes between groups and the moment of evaluation within groups. Participants were 13 under-15 year-old male soccer players from Montevideo, Uruguay, with an average of 9.38 years of competitive experience. The experimental group went through 10 individual weekly sessions of training in self-regulatory processes comprising 11 out of 18 self-regulatory processes presented in Zimerman's Multiphasic Cycle of Self Regulatory Processes. Greater improvement on the cognitive representation of tactics was observed in the experimental group, which revealed more functionally organized clustering of offensive and defensive team-specific tactical concepts in long-term memory after the training. Results showed significant differences in the organization of tactical knowledge in long-term memory due to the participation in a training program on self-regulatory processes focusing on tactical actions in soccer. This study extended the effects of self-regulatory processes, previously evidenced in specific situations in other sports, to the organization of tactics mental representation in soccer. The effects are related to the facilitation of learning processes caused by the use of self-regulatory processes. The systematic application of learning strategies adapted to tactical situations seemed to enable participants to organize tactical knowledge in long-term memory.

Key words: sport expertise, long-term memory, cognitive representation, team-specific tactics, self-regulatory processes, soccer

Résumé – Effets des processus d'autorégulation sur la représentation cognitive des tactiques spécifiques aux équipes chez les jeunes joueurs de football. La présente étude vise à démontrer la relation entre les variables cognitives et comportementales qui configurent la performance d'un expert en vérifiant si les processus d'autorégulation de l'apprentissage influenceraient l'organisation de la représentation mentale des tactiques au football. Un modèle de type 2×2 a été appliqué en manipulant le niveau des processus d'autorégulation de l'apprentissage entre les groupes et le moment de l'évaluation au sein des groupes. Les participants étaient 13 joueurs masculins de moins de 15 ans de Montevideo, Uruguay, avec une moyenne de 9,38 ans d'expérience en compétition. Le groupe expérimental a suivi 10 semaines de séance individuelle d'apprentissage dans les processus d'autorégulation comprenant 11 sur 18 processus d'autorégulation présentés dans le cycle multiphasique de l'autorégulation de Zimmerman. Une grande amélioration sur la représentation cognitive des tactiques du groupe expérimental révélant un regroupement plus fonctionnel et organisé des méthodes tactiques offensives et défensives dans la mémoire à long terme après l'apprentissage a été observée. Les résultats ont montré des différences significatives dans l'organisation des connaissances tactiques dans la mémoire à long terme du fait de la participation à un programme d'apprentissage sur les processus d'autorégulation portant sur les tactiques de football. Cette étude a étendu les effets des processus d'autorégulation, antérieurement prouvés dans des situations spécifiques dans d'autres sports, à l'organisation de la représentation mentale des tactiques de football. Ces effets sont attribuables à la facilitation des processus

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d'apprentissage provoqués par l'usage des processus d'autorégulation. L'application systématique des stratégies d'apprentissage adaptées aux situations tactiques semble permettre aux participants d'organiser les connaissances tactiques dans la mémoire à long terme.

Mots clés : expertise sportive, mémoire à long terme, représentation cognitive, tactiques spécifiques à une équipe, processus d'autorégulation, football

1 Introduction

Understanding the relationship between cognitive and behavioral variables that characterize expert tactical performance appears to be a viable way to propose an empirically supported theoretical framework that allows prediction and control of expertise development in sports, leading to technological derivations applied to learning and training.

Results obtained in studies under the expert *versus* novices paradigm have demonstrated that the structure of cognitive representations in long-term memory, the use of self-regulatory processes and effectiveness in tactical decisions appear to be common elements that characterize the level of sporting proficiency in various sports codes (Bläsing & Schack, 2012; Cleary, Zimmerman, & Keating, 2006; Kitsantas & Zimmerman, 2002; Kitsantas, Zimmerman, & Cleary, 2000; Lex, Essig, Knoblauch, & Schack, 2015; Roca, Ford, McRobert, & Williams, 2011; Schack & Mechsner, 2006; Ward & Williams, 2003; Weigelt, Ahlmeyer, Lex, & Schack, 2011; Williams, 2002). A functional model organizing the systematic relationship between these variables, however, is yet to be formulated.

Gréhaigne & Godbout (1995) argue that the player's analytical behavior in an action under significant time constraints seems to be conducted with reference to the recognition of some typical configurations of plays and their predictors, proposing a relationship between long-term memory and tactical performance. With experience, athletes would store an array of actions, assimilating and refining data collected on an image of personal mental action that would lead to quick and accurate reactions. In this sense, the quality of the cognitive representation of team-specific tactics in soccer, thus the organization of tactical knowledge, would affect anticipation and decision-making by favoring successful recall of task-specific information (Roca, *et al.*, 2011).

In addition, studies have highlighted that expert athletes have more skills in self-regulation processes compared to novice athletes granting greater control over their own cognitive and learning processes (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002). Eccles & Feltovich (2008) claimed that self-regulatory processes such as mental visualization, self-talk, goal setting, relaxation and planning favor learning control and enhance sports proficiency development.

In this research, it is conjectured that a functionally organized cognitive representation of team-specific tactics in soccer, evidenced in expert athletes, leads to expert tactic performance and it can be promoted by the use of self-regulation processes (metacognitive and motivational skills). Chi (2006) emphasizes the relationship between self-regulation, learning and memory, pointing out self-monitoring as a critical aspect in the process of acquiring knowledge and skills associated with expertise. This forecast is plausible considering that studies showed the effectiveness of training in self-regulatory processes on maximizing learning in academic and sport contexts (Cleary & Zimmerman, 2004; Cleary, Platten, & Nelson, 2008; Cleary, *et al.*, 2006; Schmitz & Wiese, 2006; Thellwell & Maynard, 2003; Zimmerman & Kitsantas, 1997).

The experiment conducted in this research aimed to contribute testing a cognitive model for tactical performance in youth male soccer players under the assumption that training in self-regulatory processes causes significant changes in the organization of cognitive representations of team-specific tactics in soccer that will lead to better tactical decision making.

This research is justified by compelling incentive from soccer coaches and officials to conduct applied research aimed at the optimization of the performance of athletes in transition for sport specialization. This finding coincides with the interest in the investigation of memory in relation to sports expertise, stimulated by studies of Chase & Simon (1973) and Chi (1978), and leveraged by recent development of instruments and objective ecological techniques that assess the characteristics of mental representations and self-regulatory processes (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 1998; Lex, *et al.*, 2015).

1.1 Mental representation of tactics and sport expertise

Recent research using software for categorization analysis has elucidated the role of mental representations in the organization of motor actions in studies of bimanual coordination, serial learning, neurophysiology of exercise and sports performance. Research showed that mental representations seem to functionally mediate perception of events and the execution of actions helping to functionally classify a variety of information for decision-making (Ericsson, 2003; Jeannerod, 2004; Koch & Hoffmann, 2000; Schack, 2012; Schack & Mechsner, 2006; Tenenbaum, 2003; Weigelt, Rieger, Mechsner, & Prinz, 2007).

Lex *et al.* (2015) conducted a pioneering study that showed level of expertise dependent differences in cognitive representations of team-specific tactics in soccer. The authors used their newly developed method for evaluating the structural organization of tactical knowledge in soccer and evidenced the important role of cognitive representations of team-specific tactics in soccer in the development of expert sport performance. The study showed that expert athletes organized tactical concepts in more functional clusters according to the task demands (Lex, *et al.*, 2015), just as Chase and Simon had revealed in 1973 with the analysis of memory in chess players.

The scientific literature addressing mental representation in relation to sports tactical performance is still scarce and it is, mostly, checking differences in memory structures between experts and non experts, requiring the implementation of experimental studies to identify the relationship between mental representation and other cognitive variables that shape expert performance (Bläsing & Schack, 2012; Bläsing, Tenenbaum, & Schack, 2009; Lex, *et al.*, 2015; Schack, 2004; Schack & Bar-Eli, 2007; Schack & Hackfort, 2007; Velentzas, Heinen, & Schack, 2011; Velentzas, Heinen, Tenenbaum, & Schack, 2010; Weigelt, *et al.*, 2011).

This present study is set to contribute to the examination of the effects of self-regulatory processes on cognitive representations of tactics as part of a cognitive model for tactical performance, having developmental male soccer as an initial analytic field. In addition, it also points to the potential use of training in self-regulatory processes as an intervention strategy for the optimization of performance and talent development, yet to be demonstrated.

1.2 The role of self-regulatory processes in the development of expertise

The comparison of expert and novice athletes delivered that expert athletes systematically apply a set of self-regulatory processes, which doesn't occur in the other group (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002; Toering, Elferink-Gemser, Jordet, & Visscher, 2009). These expert athletes, for instance, set training goals, showed better perception of self-efficacy, used more strategies related to technique and attributed the failure to the shortcomings of specific techniques.

Furthermore, according to Hodges, Starkes & MacMahon (2006) and Thomas, Gallagher & Lowry (2003), early talents derived more knowledge of sports training compared to their peers with the same amount of experience. Corroborating this finding, Chi (1978) suggests that the acquisition of appropriate knowledge structures allowed the circumvention of differences in performance related to age or practice time.

From this perspective, early talents would have used different mechanisms for learning during training, helping them benefit more from sport practice and it is conjectured that self-regulatory processes might characterize the strategies used. This possibility was pointed up by Cleary *et al.* (2006), who evidenced that novice athletes trained to use self-regulatory processes showed better sports skills and more positive motivational beliefs during technical and tactical training sessions compared to a control group. The results suggest the effectiveness of training in self-regulatory processes on optimizing performance, making up for the short time experience.

Thus, training of self-regulatory processes facilitates the encoding of relevant environmental cues by the practice of attentional strategies, information processing through an ongoing interaction with long-term memory, and decision-making related to action representation and action execution (Lex, *et al.*, 2015; Tenenbaum & Land, 2009).

1.3 Effect of self-regulatory processes on tactics cognitive representation

The interest in analyzing the effects of training in self-regulatory processes contemplated in this research is associated with the hypothesis that it can influence sports tactical performance by optimizing knowledge acquisition. Training in self-regulatory processes would help athletes to benefit more from the tactical training sessions and competitions, producing positive effects on the tactical performance by modifying the representation structures of tactics.

By showing that the quality of self-regulatory processes in the learner is more predictive of performance than knowledge of the technique and years of experience, researches of Cleary & Zimmerman (2001), Kitsantas & Zimmerman (1998, 2002), Kitsantas *et al.* (2000) and Toering *et al.* (2009) led to conjecture that the use of these processes would increase learning in sports context through the functional organization of knowledge in the athlete's long-term memory.

Hodges *et al.* (2006) and Thomas *et al.* (2003) concluded that young athletes who have become early talents derived further knowledge from practice compared to their peers. The authors assumed that these athletes applied different learning mechanisms during practice, helping them benefit more than the average athlete. The applied learning mechanisms have mainly been characterized by self-regulatory processes.

Thus, self-regulatory processes are associated with the modification of the structure of mental representations of actions and tactics because they have an effect on learning and performance. Additional evidence is delivered by studies showing the effectiveness of training in self-regulatory processes in optimizing learning in academic and sporting contexts (Cleary & Zimmerman, 2004; Cleary *et al.*, 2006, 2008; Schmitz & Wiese, 2006; Thellwell & Maynard, 2003; Zimmerman & Kitsantas, 1997). The present research supports that training in self-regulatory process produces changes in the organization of tactical knowledge in long-term memory (cognitive representation of team-specific tactics in soccer).

2 Method

2.1 Participants

Thirteen under-15 year-old male soccer players ($M = 14.15$ years, $SD = 0.38$) from Montevideo (Uruguay) were recruited and had a mean of 9.38 years ($SD = 1.45$) of competitive soccer experience. At the time the research was conducted, participants were competing for a local club in the first division of the national league, a high level tournament composed by 16 teams in which the mentioned club has been top 5 with the most championships.

2.2 Measures and instruments

2.2.1 Assessment of the cognitive representations of team-specific tactics in soccer

The cognitive representation of team-specific tactics in soccer was assessed through an implicit cognitive measurement named Structural-Dimensional Analysis of Mental Representations (Schack, 2012), further developed to measure match situations in soccer (Lex, *et al.*, 2015). The method consists of a comparative task between 12 stimuli (match situations displayed on a coach's whiteboard from a bird's eye perspective) comprising defensive team-specific tactics: *back to defense* (match situations 1 to 3) and *pressing* (match situations 4 to 6); and offensive team-specific tactics: *change sides* (match situations 7 to 9), and *counter attack* (match situations 10 to 12). The match situations were presented by beamer on a projection wall. Each match situation was compared with every other match situation with regard to conceptual similarity. Thus, the question for the participants was: Does your team react in the similar way in the presented match situations? The comparison was made in pairs. If participants thought both match situations are solved with a similar tactical behavior by their team they marked their decision with a plus sign, if not they used a minus sign on the answering sheet.

2.3 Design and procedures

A 2×2 mixed experimental design was applied, manipulating the level of training in self-regulatory processes between groups (experimental and control) and the moment of evaluation (pre and post-test) within groups. The cognitive representation structure of team-specific tactics was used as dependent variable, being represented and analyzed by the dendrograms. Participants were randomly assigned to either the experimental group ($N = 6$) that went through a ten sessions training in self-regulatory processes or to a control group ($N = 7$).

Having gained informed consent, both groups had the cognitive representations of team-specific tactics in soccer assessed on a pre-test. Participants were informed about the nature of the task and that they should make their response on impulse, but without any time pressure. The data acquisition lasted for one hour, and was divided in two phases. The first phase consisted of a block of familiarization trials comprised of four match situations (*i.e.* not used in the test) to be compared with each other. In the subsequent second phase, the participants were requested to clarify any doubts about the procedure, after which the data acquisition began. The participants started comparing all twelve match situations with each other.

One week after the pre-test took place, the intervention program started. The experimental group went through a ten sessions (three months) training program in self-regulatory processes. One week after the intervention, all participants were evaluated on the post-test with the same instrument.

2.3.1 Training program in self-regulatory processes applied to the optimization of tactics mental representation (TPSR-TMR)

Eleven out of the 18 self-regulatory processes suggested by Zimmerman & Campillo (2003) were included in the training program in a way that all three phases of the multiphasic self-regulatory cycle were covered and a substantial variety of sub processes were approached. Processes included from the *forethought phase* were goal setting, strategic planning, task value, and self-efficacy. The *performance phase* was represented by the sub processes: self-instruction, imagery, self-recording, and self-monitoring, while from the *reflection phase*, self-evaluation, causal attribution and adaptive/defensive reaction were addressed.

Sessions were held individually once a week for 20 minutes and took place in the conference room of the club's high-performance training center where the athletes practiced regularly. The room was private, well ventilated and illuminated. The training program focused on the use of self-regulatory processes driven to tactical actions and was comprised of cognitive strategies such as self-assessment on the use of self-regulatory processes and complementary daily task assignment as a way to optimize learning in spite of time constraints imposed by the sessions.

The essential components of the training program in self-regulatory processes are highlighted: (a) sequence and content of sessions and (b) emphasis on cognitive awareness (for a full description see Vorraber, 2016).

The initial components of the training involved education on the cycle of multiphasic self-regulatory processes and it's relation to sport and academic performance, self-assessment and self-awareness. At this stage, athletes were asked to rank offensive and defensive tactical principles according to the level of ability perceived in each and chose the most relevant for their position to set goals and achievement strategies such as penetration, offensive coverage, width and length, depth mobility, offensive unity, delay, defensive coverage, balance, concentration and defensive unity (Teoldo, Garganta, Greco, Mesquita, & Afonso, 2010). Conceptual maps were used to permit the decomposition and association of target tactical principles into observable behaviors that should be targeted by the goal setting. For example, penetration was often linked to physical abilities such as speed and aerobic resistance, as well as cognitive skills like anticipation of the players' movements and ball paths and concentration. The decomposition of a tactical principle into more specific elements facilitates planning

Table 1. Summary of techniques that conformed the training of self-regulatory processes applied to the optimization of tactics mental representation.

Technique	Description	Goal
Self-assessment	Ranking of offensive and defensive principles according to level of ability perceived and relevance to the position in the team	Acknowledge principles of interest for the goal setting and strategic planning procedures
Conceptual map	Decomposition of target tactical principles into specific observable behavior	Specification of observable behaviors for goal setting and strategic planning procedures
Goal setting and strategic planning	Listing of expected observable behavior according to target tactical principles to be checked every week and associate strategies to be adopted in order to achieve them. The observable behavior was related to a process more than to an outcome	Set specific and observable tactical goals and plan objective strategies to achieve it
Thought record	Daily recording, evaluation and validation of automatic thoughts regarding the execution of tactical tasks and self-efficacy	Tackle and adapt task interest and self-efficacy thoughts
Biofeedback	Electronic monitoring of physiological responses used to train self-awareness and self-control of cognitive processes such as thoughts and imagery	Stimulate and guide on the use of self-talk and visualization routines in order to make them more frequent, positive and functional
Self-record form and analysis of content	Filling out and analysis of content on self-record form where the participant records the strategy adopted to make decisions during tactical practice, evaluation of the action process, causes attributed to the failure or success, reaction and possible strategic changes to be made	Promote self-monitoring, self-recording and gather data to reflect on to adjust practices of self-evaluation, causal attribution and adaptive reaction

and monitoring. Interest for the task and self-efficacy were tackled through cognitive techniques such as thought record and analysis of its contents.

Self-instruction and imagery were addressed through the use of the biofeedback technique, which helps educate the athlete on the effects of cognition on their physiological state and creates a better understanding and motivation about the relevance of applying functional visual and verbal mental routines. While still on the performance phase sub processes, both self-monitoring and self-recording were very practically administered. Athletes received a sheet with information to be filled out regarding self-regulatory strategies used during tactical practice, its effectiveness, outcomes and possible adjustments.

Intervention on self-evaluation, causal attribution and adaptive/defensive reaction was carried out through the discussion and reflection about the information contained in the self-monitoring and self-registering forms. Athletes were asked to attribute grades to their tactical performance every week and consider possible causes for the outcomes. They were taught the effectiveness of different attributions on human performance, ranging from uncontrollable external to controllable internal causes. Based on the reflection, they were asked to apply new adaptive inferences to favor the adjustment of strategies used during tactical actions (Tab. 1).

2.4 Data analysis

The hypothesis that the intervention in self-regulatory processes would optimize the organization of cognitive representations of team-specific tactics in soccer was tested by qualitative comparison of the functional organization of the representation structures between experimental and control group in the pre and post-test.

The measurement of cognitive representations of team-specific tactics in soccer consisted of three steps. First, the participants made their decisions between all match situations ($N = 132$ decisions of each participant) in a splitting procedure. Figure 1 shows the presentation of match situation in the splitting procedure, which demands one match situation in anchoring position (presented on the left) compared stepwise with every other match situations (presented on the right).

Once all comparisons with regard to the anchoring position were made, the next match situation went into the anchoring position and was compared with every other match situation again. This splitting procedure lasted until every match situation was in the anchoring position once.

The participants' decision in this splitting procedure formed a positive and negative subset for all match situations, in which each match situation received a

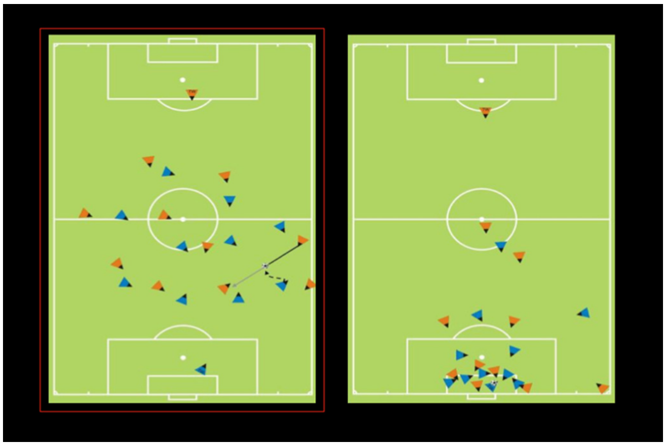

Fig. 1. Presentation of match situations showing typical team-specific tactics. Players are depicted as triangles including a black apex (indicating viewing directions of the player). Participants' perspective is from the blue team with the playing direction upwards.

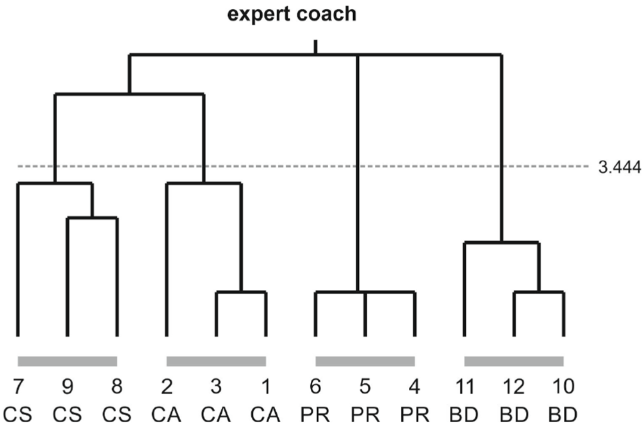

Fig. 2. Cognitive representation of an expert coach. The numbers at the bottom represent the twelve different match situations. Each match situation corresponds to one out of team-specific tactics (CS – change sides, CA – counter attack, PR – pressing, BD – back to defense). The height of the conjunctions represents the Euclidean distance between the match situations. The dashed line represents the critical Euclidean distance where all branches were cut off. All match situations connected to one branch below the critical Euclidean distance form a cluster. Each cluster is indicated by a grey bar at the bottom of the figure.

value (*i.e.* positive or negative according to participant's decision) reflecting its similarity to the anchoring match situation. This procedure resulted in a vector of values for each anchored situation, which were concatenated into an array of values in a matrix. Each row of the matrix corresponded to one match situation and was transformed by a z-normalization to convert into relative position each match situation in a multidimensional space. This standardized position matrix was transferred into a Euclidean distance matrix including all match situations.

Second, the Euclidian distance matrix forms the basis for an unweighted average linkage hierarchical cluster analysis to identify clusters within the match situation based on participant's decisions. The Euclidian distance between certain match situations is reflected by the height of the conjunctions in the dendrograms. A critical Euclidean distance ($d_{\text{crit}} = 3.44$) was estimated based on the total number of match situations assuming an error probability of $p = 0.05$. All match situations connected to one branch below the critical distance form a cluster. The evolved clusters are indicated by grey bars at the bottom of the dendrograms.

Third, the evolved cluster structures were tested for structural homogeneity using an invariance measure between the averaged group dendrograms. The statistical threshold for accepting invariance between the representation structures was set to $\lambda = 0.68$. The qualitative comparison of the evolved representation structures was held based on representation structures of an expert soccer coach (Lex, *et al.*, 2015). Thus, an ideal representation structure of tactics in soccer was expected to present discriminated clusters of offense and defense, as well as its sub-concepts (changing sides and counter-attack in the offensive cluster and pressing and back to defense in the defensive cluster).

3 Results

Figure 2 shows the cognitive representation structure of a highly experienced coach (42 years, 1. Bundesliga & Champions League, UEFA Pro License). The cognitive representation is characterized by clear and distinct separation of all four team-specific tactics of counter-attack, change sides, back to defense, and pressing. This representation structure corresponds to the theoretical separation of the team-specific tactics and represents a functional cognitive representation structure of team-specific tactics in soccer. Thus, this cognitive representation serves as a reference structure. Additionally, this representation structure of team-specific tactics is identical to the representation structure of more experienced adult soccer athletes playing in the highest German amateur league (Lex, *et al.*, 2015).

Figure 3 shows the representation structures of the experimental (a) and control (b) group in the pre-test condition. Both cognitive representation structures contain four clusters (indicated by the grey bars at the bottom) each. With relation to team-specific tactics the cluster pressing (including the match situations 5 and 6) indicates the establishment of functional structure as well as a change sides cluster (containing the match situations 7, 8 and 9) within the control group. All other clusters integrate match situations of different team-specific tactics, and even different global team-specific tactics (*i.e.*, within or without ball possession). The invariance measure shows that the cognitive representation of the experimental ($\lambda = 0.54$) as well as cognitive representation

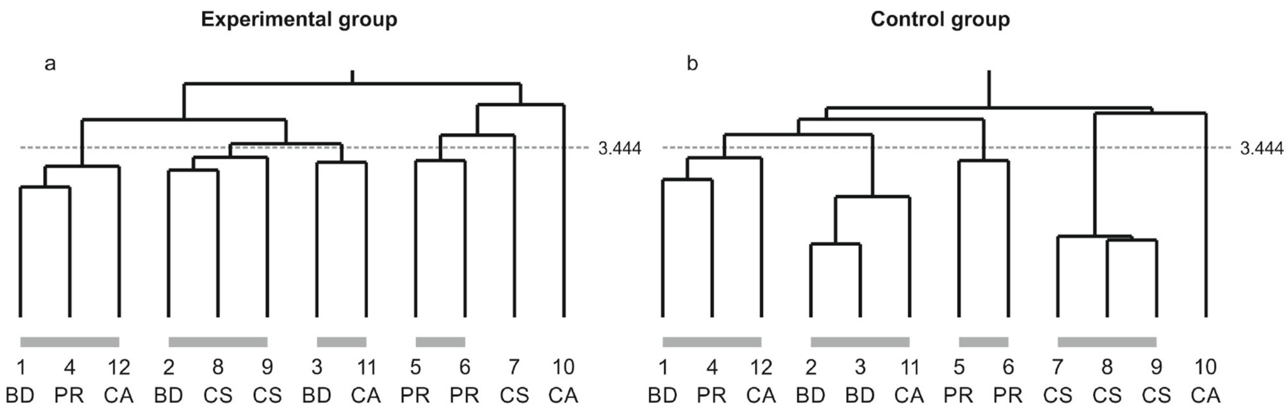

Fig. 3. Cognitive representation of the experimental (a) and the control (b) group in the pre-test. The abbreviations as well as the signs and symbols are identical to Figure 2.

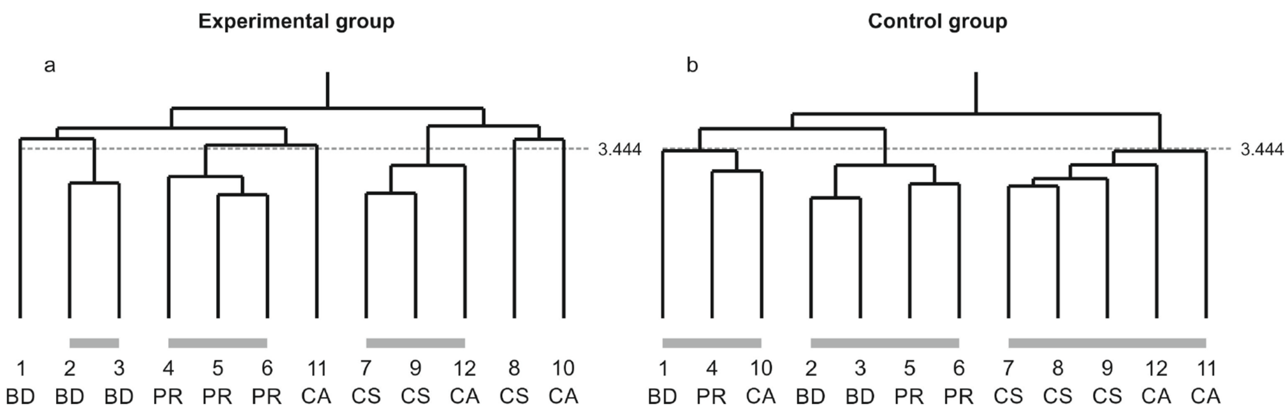

Fig. 4. Cognitive representation of the experimental (a) and the control (b) group in the post-test. The abbreviations as well as the signs and symbols are identical to Figure 2.

of the control group ($\lambda = 0.65$) are not invariant ($\lambda < 0.68$; Schack, 2004) to the reference structure.

Figure 4 shows the cognitive representation of team-specific tactics in soccer of experimental (a) and control group (b) in the post-test condition. Generally, both representation structures indicate from a top-down approach the separation of two classes mainly on the left and on the right representing the team-specific tactics within and without ball possession. Moreover, both groups reveal three statistically significant clusters. However, the differences between the representation structures of both groups are obvious.

The invariance measure shows that the representation structure of the experimental group is invariant ($\lambda = 0.77$) to the reference structure. Thus, these representation structures can be treated as similar to each other. The similarities are described by the cluster pressing (including the match situations 4–6), the cluster back to defense (match situations 2 and 3; match situation 1 is already connected that cluster), and the cluster changes sides (match situations 7, 9 and 12), even though match situation 12 belongs to counter attack. The match situations 8, 10 and 11 represent singled match situations, which need to be integrated to form an ideal representation structure.

The representation structure of the control group is not invariant to the reference structure ($\lambda = 0.49$). That representation structure forms one cluster (match situations 1, 4 and 10) integrating nearly all team-specific tactics. The two other clusters integrate at least two out of four team-specific tactics separated by ball possession (*i.e.*, within or without). Such a distinction is less functional with regard to team-specific tactics for highly skilled athletes.

Thus, it appears that the cognitive representation of team-specific tactics in soccer is influenced by an intervention focusing on self-regulatory processes. It seems that highly skilled athletes that underwent such an intervention are more aware of team-specific training interventions. They benefit from tactical training sessions because they use directed attentive strategies within soccer-specific learning scenarios.

4 Discussion

The sophistication of cognitive representation of tactics shown by the experimental group after the intervention can be associated with positive effects of self-regulatory strategies that according to Tenenbaum & Land (2009) mainly stimulated 3 cognitive processes during its application: (1) encoding of contextual clue by the adaptation of attentional strategies; (2) information processing by the permanent interaction with long-term memory and; (3) constant monitoring of decision-making during action.

In contrast, the control group appeared to regress in terms of functionality of the organization of tactical concepts in long-term memory by grouping offensive and defensive sub concepts into their basic major categories. We can describe the results as primitive based on the functional discrimination of basic concepts and sub concepts and it can be conjectured that the lack of systematic and intentional learning could permit a setback in conceptual organization of knowledge in long-term memory. The group that didn't use learning strategies seemed to go back to the most generalized structure of knowledge organization, represented here by the two major categories of tactical concepts, defense and offense.

The experiment set out significant differences in the organization of tactical knowledge in long-term memory as an effect of participation in a training program in self-regulatory processes focusing on tactical actions in soccer. The literature had already pointed out the effectiveness of these processes in the optimization of motor performance on free throws in basketball and on overall performance of cricketers, (Cleary, *et al.*, 2006; Thellwell & Maynard, 2003). This study, however, extended the effects of training in self-regulatory processes to the organization of cognitive representations of team-specific tactics in soccer, pointing to a possible mediating role of the latter in technical performance evidenced in previous studies and in the tactical performance functional model.

Self-regulatory processes seem to influence knowledge acquisition due to its effect on the optimization of attentional processes, information processing and decision-making, according to previous studies of Lex *et al.* (2015) and Tenenbaum & Land (2009). The systematic application of task analysis, self-motivation, self-control, self-observation, self-judgment and self-reaction seemed to enable participants with learning strategies that helped the organization of tactical knowledge in long-term memory.

Mental representation in sports context is still a theme with scarce literature and empirical studies and it is recommended to include female subjects in future researches in the topic. Current findings, however, relate it to high levels of sporting proficiency in various sports codes. According to the present study, there is evidence that sustains the mediating role of self-regulatory processes over cognitive representation of concepts in long-term memory in youth male soccer players. The findings contribute to the elaboration of a cognitive model for tactical performance that affords the relationship between cognitive and behavioral processes.

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