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Functional Mental Representation of Volleyball Routines in German Youth Female National Players

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The purpose of this study was to examine the overhand volleyball service routines of the German Youth Female National Team. Mental representations of this movement were reconstructed using the Structure Dimensional Analysis-Motoric method. The Routine Questionnaire was administered to collect self-report data. Results indicated that the mental representations of routines are organized in a hierarchical, tree-like structure. The movement mental representations of players not selected to the national team were organized in a less hierarchical manner. The coach's performance ranking was significantly correlated to the athlete's mental representation invariance values (structure quality), indicating a close relationship between mental representation and performance.

New methods aimed at helping athletes stabilize and optimize their skills are of utmost importance in elite sport. Several psychological models and theories have been formulated to clarify the guidelines for a perfect competitive mental preparation, and to evaluate diverse psychological skill development (Taylor, 1995; Wrisberg & Anshel, 1989). The application and refining of such skills can be conceptualized as performance routines (Cohn, 1990). Singer (1986) was one of the first investigators who proposed the systematical integration of routines into the movement approach, suggesting that the use of performance routines secure appropriate mental preparation by assisting the athlete to self-regulate, pay attention, and then perform automatically the task at hand (Lidor, 2009; Singer, 2002). From this point of view, the evaluation of performance routines and their integration into the movement approach is a vital factor for a successful performance. However, the evaluation of used routines is most often based on a combination of self-reports or interviews, performance observation, or movement analysis and it can be a time-consuming process (Schack, Whitmarsh, Pike, & Redden, 2005).

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Routines are defined as plans, strategies, or techniques, which can help athletes to enhance their performance (Singer, 2002). Accordingly, routines function much like a scanning device, and they can enable athletes in evaluating the competition conditions. Performance routines include cognitive (covert) and behavioral (overt) components (Cohn, 1990), which can be further subdivided into pre-performance, between- or quick set-, and post-performance routines. The significance of these subcomponents to movement learning and outcome has been systematically scrutinized in different sports (Boutcher & Crews, 1987; Cohn, Rottella, & Lloyd, 1990; Foster, Weigand, & Baines, 2006; Robazza & Bortoli, 1998). Depending on their physical and mental state in conjunction with game-related stressors, such as game score or time pressure, participants can decide about the format and the duration of the performance routines they plan to use (Cotterill, Sanders, & Collins, 2010; Schack et al., 2005).

An important product of routines is the creation of a mindset that initiates optimal physiological preparation and cultivates athletes' performance. A positive mindset includes, for instance, establishing a performance goal, generating a positive mental rehearsal, and identifying mental tools (e.g., self-instruction) that can result in improved responses. This mindset acts as the foundation for all actions related to competitive performance. The frame of mind, however, sets only the tone for optimal performance. Routines must also include mental tools (e.g., cue words) that put the mindset into action.

Cognitive components of routines may include self-talk (Bunker & Owens, 1985; Bunker & Rotella, 1982) including (performance-stabilizing) cue words (Boutcher, 1990; Lidor, 2009), focus (Kendall, Hrycaiko, Martin, & Kendall, 1990; Murphy, 1994), mental imagery (Guillot & Collet, 2005; Mahoney & Avener, 1977), and psyching up (Caudill, Weinberg, & Jackson, 1983; Shelton & Mahoney, 1978). Consequently, these components can be thought of as tools that athletes could use to direct attention to the essential task-relevant information, thus ensuring proper athletic execution and coping with an emerging situation (Schack, et al., 2005).

Additionally, behavioral components of routines may include practice attempts (e.g., practice swings in golf) or rhythmic movement that helps initiate successful performances (e.g., bouncing the basketball prior to a free throw). For example, bouncing a ball in a volleyball service routine provides the server with feedback about the ball properties, the surface conditions, and the tonus of their muscles. This information can then be used to optimally prepare for the service execution. Routines also enable athletes to adjust and fine-tune their preparations in pursuit of their particular competitive goal (Gammage, Hall, & Rodgers, 2000). Nevertheless, studies conducted in a number of sports including wrestling and diving (Highlen & Bennett, 1983), golf (Cohn, Rotella, & Lloyd, 1990; Rotella & Bunker, 1981), tennis (Moore, 1986), gymnastics (Zaichkowsky, 1983), and volleyball (Kolscher, 1984; Lidor & Mayan, 2005), demonstrated that routines that contain both cognitive and behavioral components, are effective in improving performance.

Generally, in applied sport psychology, videotaping and performance observations are used to analyze performance behaviors. Along with time calculation, the latter can be used to measure and scrutinize the use and consistency of routines. Additionally, interviews and/or self-report methods can serve in identifying cognitive components of routines (Lidor, 2007).

In Cohn's (1990) review, he discussed the most important theories for capturing the use of performance routines, highlighting among others the schema theory which was developed by Schmidt (1975). Schmidt suggested that motor knowledge is stored in memory as a major program (i.e., containing sensory, spatial, and feedback information) that can be retrieved for the recognition and mastery of a motor task (see also, Schmidt & Lee, 1999). The assumption that movements are well-structured concepts, stored hierarchically in long-term memory that can be recalled and reproduced at any time, serves as the basis of cognitive action architecture theory (Schack, 2004). Schack (2004) assumed that single-movement concepts are summarized in a bottom-up procedure into phases or so called sub-movement solutions. In a higher level, phases get interconnected (phase integration) building the main movement phases. Finally, the summary of sub- and main-movement phases offers the movement solution or the whole movement mental representation.Thus, motor programs become more precise and detailed with experience and practice, resulting in performance optimization. This process, therefore, supports the automaticity of the movement execution. Schack (2003) hypothesized that motor expertise is characterized by well-integrated networks of perceptual-cognitive concepts, referred to as basic action concepts (BACs), that mirror the functional demands of the respective task, and thus might afford the relevant reference structures for movement control. BACs are seen as cognitive clusters stored in long-term memory, integrating anticipated movement effects and their related outcomes to serve the execution of movement tasks. The storage of the movement relevant BACs in long-term memory can be evaluated using the Structural Dimensional Analysis-Motoric (SDA-M) method (Schack, 2003).

The SDA-M is administered by means of a laptop computer and consists of three steps. First, a special split procedure is used that results in a distance scaling between the BACs of a predetermined set. During this split procedure, the participant has to compare each BAC with each other BAC in terms of their functional and structural similarity. Second, a structure analysis (i.e., cluster analysis) is conducted to explore the underlying structure of the BACs. The third step consists of analyses of invariance in which all individual cluster solutions are analyzed for likeness within and between groups and with regard to a biomechanical and psychological derived optimal structure. A very important aspect of the SDA-M is that participants are not asked to give explicit statements regarding their representation structures, but rather this structure is revealed by means of knowledge-based decisions in an experimental setting.

The SDA-M method using the split approach has been documented in numerous sport disciplines such as volleyball, gymnastics, wind surfing, dancing, and tennis (Bläsing, Tenenbaum, & Schack, 2009; Heinen & Velentzas, 2005; Schack, 2003; Schack & Hackfort, 2007). The results of these studies have shown that athletes of various skills provided differentiated mental representation structures. Experts' movement mental representation covered clearly the functional and temporal demands of complex movements, whereas novices provided a less clearly structured movement mental representation (Schack & Hackfort, 2007). From this point of view, the significant relationship between the expertise level and a well-structured movement representation was established.

Altogether, empirical findings support the assumption that mental routines enhance performance and facilitate the learning process (for an overview, see Lidor, 2007). The measurement of cognitive and behavioral routines was done by means of self-reports, interviews, and observational procedures. Routine interventions generally imply that athletes have to follow a master plan without being cognizant of the routine selection procedure. Only few single studies are devoted to athletes' needs or preferences and how they can be defined (e.g., Kolscher, 1984; Liu & Zhang, 2003). However, it seems necessary that an intervention should be based on performance routines of experts (Cotterill et al., 2010). Thus, the SDA-M approach can be used as a tool for measuring mental representation, and provide information about movement structures in long-term memory. Theoretically, the SDA-M paradigm can be applied to verify the association of performance routines to the distinct movement phases, and to provide a method that can quantify mental representation of routines, and make them readily accessible in the form of a tree-like diagram (Bläsing, et al., 2009; Schack & Hackfort, 2007; Schack & Mechsner, 2006).

The aim of this study was to introduce a new method for measuring mental strategies when performing overhand service in youth high-level volleyball players. This skill is temporally bounded and demands concentration, movement control, and accuracy. Furthermore, the relationship between the structure of mental representation, routine integration and the task of the players (playing positions) were of particular interest in our study.

METHOD

Participants

Twenty-nine female volleyball players from the extended German Youth Female National Volleyball Team squad ($M = 17$ yrs, $SD = 1$ yr) participated in this study. The average daily training of the participants was 3 ± 1 hr. All athletes played in the first or second national division and reported between 8–10 years of prior volleyball experience. Participants were members of twelve different German sport clubs selected for the German Youth Female National Team tryouts to the Youth European Championship.

Apparatus

Performance Rating

The head coach was asked to rate three attributes of the volleyball serve quality of each player on a 5-point Likert-type scale, ranging from 1 (*worst performance*) to 5 (*best performance*). The three attributes were (a) effectiveness, (b) stability, and (c) tactical quality of the service into one global judgment. Effectiveness was operationalized as the observed floating effect of the ball, which makes it hard to receive. Serve stability indicated the direct service errors made by the participants. Tactical quality referred to the participants' ability to serve precisely following the coach's tactical instructions. Hence, the total possible score for the rating was 15 points after summing up the three ratings. All selected performance attributes were weighted by the same percentage ratio (33.3%). The coach rerated participants with the same rating scores. Finally, the rating means of the head coach were transformed into a ranking list, in which the participant with the highest score was ranked first, and the participant with the lowest score was ranked last. The head coach was instructed to rate the players' performances as fair and honest as possible. However, the performance ranking of several volleyball skills was an inherent part of the tryout procedure, with the coach being experienced in this kind of assessment.

Routines Questionnaire (RQ)

Two independent research experts with the help of one elite coach and two independent elite volleyball players generated a pool of 15 items that reflected three sub-scales concerning the use, development, and integration of routines in training and competition. Based on these items, semi-structured (open-ended) interviews with the coaches, self-reports, and videotapes of volleyball serves including the qualitative motion analysis of the players were carried out. The main goal was the validation of the generated pool of items, determining in a first step their relevance to the sub-scales, and collecting information about the use and the temporal integration of routines into the several serve phases.

Furthermore, two other independent research experts together with two other first division coaches, and six female volleyball experts assessed the content validity of this initial pool of items by examining the substance, format, and possible usage within the volleyball population. The assessment was carried out as an open-ended discussion with the ultimate goal to approximate the items of the RQ subscales. Based on their recommendations, changes were made on the initial pool. Three items were removed due to close similarity and three other items were reformulated. At the end of this process a final pool of 12 items, with four items for each subscale, reflecting content, format, and usage, respectively was formulated. The overall test content validity ratio across the 12 items was satisfactory ($CVR = .78$; Lawshe, 1975).

The three sub-scales of the Routines Questionnaire were labeled and characterized as follows: (a) use of routines, (b) development of routines with the coach's help, and (c) integration of routines in the training process. The first sub-scale consisted of items that homed in on the general use of mental strategies in the between-performance routines of players. A typical item was, "I use mental routines (e.g., counting, visualization of the service)." Items of the second sub-scale reflected the development of routines with the assistance of the coach. An example item was, "The coach mainly guides me when developing new mental strategies (e.g., routines)." The third sub-scale included items relevant to the integration of routines in daily training. A representative item was, "I practice routine-techniques and mental strategies during my training and even afterwards." Items were arranged in a randomized order in the paper-pencil version of the RQ, and were rated on a 5-point Likert-type scale ranging from 1 (*never*) to 5 (*always*). Cronbach's alpha for the use of routines sub-scale was $\alpha = .89$, for the development of routines sub-scale $\alpha = .75$, and for the integration of routines sub-scale $\alpha = .78$. Finally, Cronbach's alpha for the entire scale was $\alpha = .88$.

Structure-Dimensional-Analysis-Motoric (SDA-M; Schack, 2004)

The SDA-M was used to assess the structure of BACs in motor memory. Following this method, each participant made $13 \times 12 = 156$ decisions using 13 BACs. Then a distance matrix was calculated from the 156 decisions for each participant, in which each BAC was weighted according to the structural and functional similarity of all other BACs. The distance matrix was then subjected to a hierarchical cluster analysis using unweighted pair group average algorithm, providing a tree diagram, showing the cluster solution of the BACs in each individual case. Because cluster solutions can differ among individuals, an additional invariance measure was performed (Schack, 2003, 2004) to assess the structural invariance between two cluster solutions. In the present analysis, two structures were declared invariant if they reached the critical invariance level of $\lambda_{crit} = .68$ with $\alpha = 5\%$ (for a more detailed description, see Schack & Hackfort, 2007).

Performing a service in volleyball requires conceptual representations not only of certain contextual states (e.g., setting up of the opponents), but also of movement sequences accompanied with psychological skills. In a preparatory step it was necessary to characterize the task-adequate functional organization of the volleyball service and to generate a plausible and useful set of BACs. This was done in collaboration with three elite volleyball coaches and three elite volleyball players from the national volleyball team. At the end of this process, a list of 13 task-relevant BACs that covered the functional structure of the serve movement was completed. This list contained both psychological and behavioral aspects with a special emphasis on routine-integration as well as the most important biomechanical cues of the overhang service (see Table 1).

BACs can be related to the five distinct phases of the overhand volleyball service. In the first stage, the athlete holds the ball and prepares for the execution of the serve itself. From a psychological point of view, general strategies like muscular preparation and self-talk tend to be emphasized by the player. The second stage is labeled the set-phase. The athlete takes position behind the base line of the volleyball court and directs attention to a target. The set-phase is followed by the third phase, the focusing-phase. Subsequently, the hit preparation phase and the hitting phase represent the fourth and fifth phase, respectively.

To ensure that the SDA-M was suitable for the applied setting in volleyball, a one-week interval temporal stability of the SDA-M was tested prior to the commencement of data collection. The temporal stability coefficient between repeated invariance measures of all individual cluster solutions and a biomechanically derived optimal structure was $r = .90$ ($p < .01$) for a sample of 40 adult elite and semi-elite senior female volleyball players ($M = 25$ yrs, $SD = 4.3$ yrs), playing in Germany's first and second volleyball divisions with an

Table 1
Structure of the Overhand Service Including the Distinct Phases and Their Movement and Routines Related BACs

(a) Regulatory-phase	**(b) Set-phase**
1) Muscle relaxation (overt/covert)	4) Locking the serve target (overt)
2) Positive self-talk (covert)	5) Breath control (covert)
3) Getting information from the coach (overt)	6) Bouncing the ball (overt)
(c) Focusing	**(d) Hit preparation**
7) Imagining the movement (covert)	9) Tossing the ball
8) Bring the ball to chest level	10) High elbow
(e) Hitting	
11) Whipping extension of arm	
12) Flick the wrist when hitting the ball	
13) Immediate readiness	

average volleyball experience of 16 years. As a reference, the mental representation structure used the experts' SDA-M results (see Figure 1).

Procedure

Twelve outside hitters, nine setters, and eight middle blockers took part in the tryouts, and therefore participated in the data collection, which took place directly after a regularly scheduled practice. All participants were informed about the goal and the procedure of the study, and gave their informed and written consent. The athletes were asked to image the serve

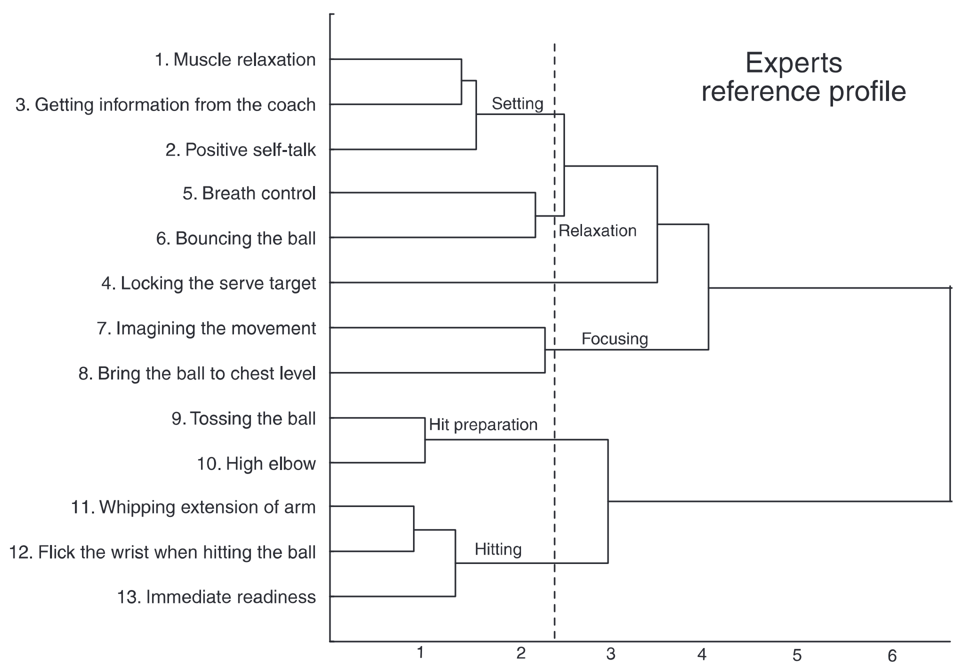

Figure 1. Average tree diagram of the experts' mental representation structure ($n = 9$; $\alpha = 5\%$; $d_{crit} = 2.45$).

movement, and afterward to carry out the first step of the structure dimensional analysis (split procedure). In this split procedure they decided which BACs are related to each other, regarding their own movement approach. The split procedure was based on 13 (BACs) × 12 (anchor) comparisons. The participants had to sort the BACs as either related or unrelated presented to them via split-lists in random order. During the experiment, and to facilitate the judgment process, players were permitted to stand up and simulate the serve movement. This procedure was chosen because specific knowledge could be more easily recalled in the environment where the athletic participation takes place (Eysenck & Keane, 2005). After completing the first step of the structural dimensional analysis, participants were asked to complete the RQ. Each participant was given 20 min to complete the first step, after a 15-min break, an additional 10 min were allowed to complete the RQ.

RESULTS

The data analysis was performed separately for players selected or non-selected from the European Championship team roster and their respective positions. We calculated Spearman's rank-order correlation between coach's ranking list and players' mental representation invariance values. This analysis revealed a correlation coefficient of $r = .82, p < .05$, indicating that higher-ranked players exhibited an increased similarity of serve mental representation to the reference mental structure (cf., Figure 1). The invariance analysis showed that selected players had a qualitatively better pronounced mental representation structure ($\lambda = .86$; $\lambda_{crit} = .68$) than the non-selected players ($\lambda = .69$; $\lambda_{crit} = .68$). As a reference for all comparisons, the mental representation structure used the experts' SDA-M profile (see Figure 1). The interpretation of the tree-diagrams allows the conclusion that the selected players have an almost-perfect

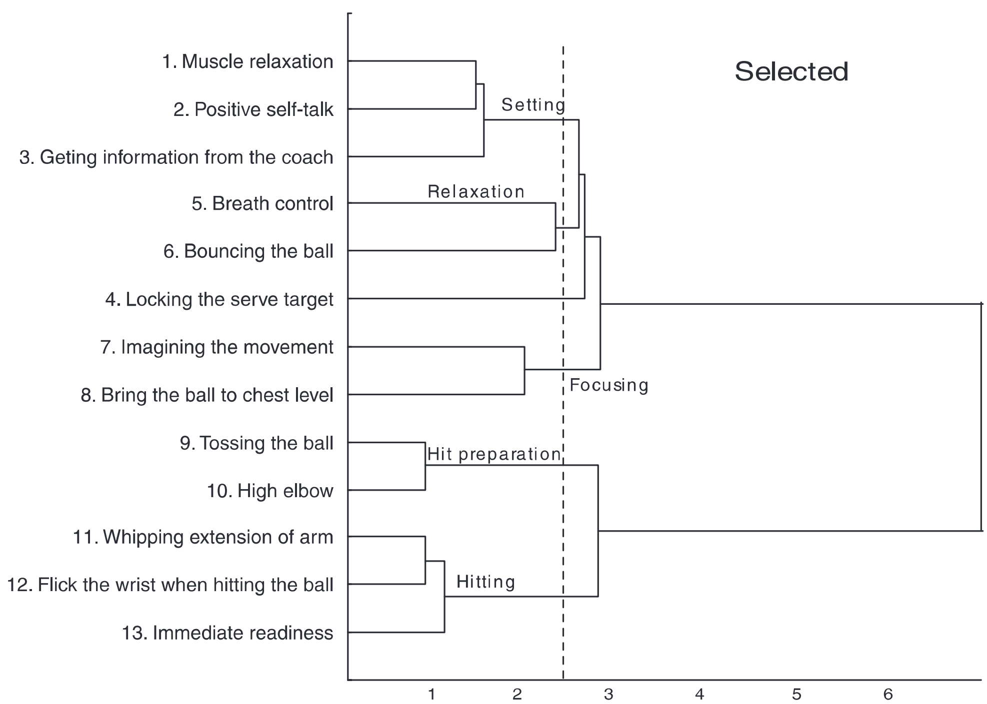

Figure 2. Structural Dimentional Analysis-Motoric results within all selected players. In these cluster solution the five phases of the serve can be easy to recognized ($n = 14$; $\alpha = 5\%$; $d_{crit} = 2.45$).

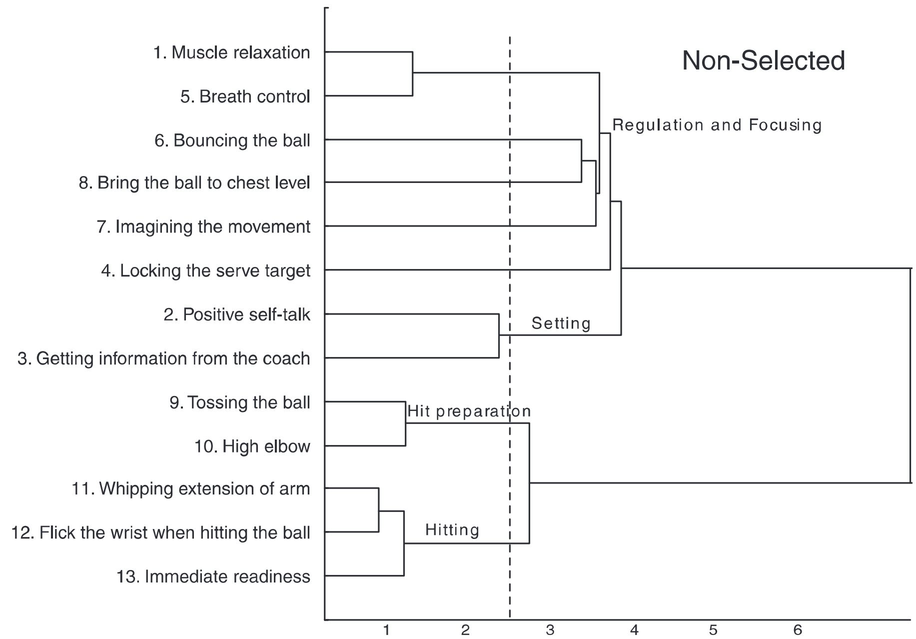

Figure 3. Cluster solution within all non-selected players. Several BACs were located slightly above the critical distance and two phases are joined ($n = 15$; $\alpha = 5\%$; $d_{crit} = 2.45$).

memory structure of the overhand service (see Figure 2). The five phases (i.e., clusters) were easily recognized, and the biomechanical and the routines' BACs were correctly stored in the movement phases according to the functional demands of the movement. The group SDA-M results of all the non-selected players showed a somewhat weaker structural link between the BACs. Several movement and routine BACs (see Figure 3) were linked to the critical distance, implying that they are not a significant part of the cluster solution.

Furthermore, emphasizing the different playing positions for all participants, outside hitters provided an invariance score of $\lambda = .75$, setters of $\lambda = .76$, and middle blockers provided a score of $\lambda = .61$. For a more differentiate comparison, we calculated the invariance values with regard to the coach selection and the players' positions. The analysis revealed that the invariance for the selected setters was $\lambda = .82$, for the selected outside hitters $\lambda = .82$, and for the selected middle blockers $\lambda = .75$. Additionally, the invariance values for non-selected players were $\lambda = .73$ for setters, $\lambda = .69$ for outside hitters, and $\lambda = .57$ for middle blockers (see Table 2).

The results of the RQ showed no significant differences in any of the three factors between the selected and the non-selected players. The corresponding F-values resulting from the analysis of variance (ANOVA) procedure were (a) use of routines, $F(1,23) = .15$, $p = .69$; (b) development of routines, $F(1,23) = .27$, $p = .60$; and (c) integration of routines, $F(1,23) = .07$, $p = .80$.

DISCUSSION

Previous and current research findings highlighted the positive effect of using cognitive and behavioral routines on athletes' performance and on movement learning process (Cohn, 1990; Lidor, 2007; Singer & Chen, 1994). The overhand service in volleyball is regarded

Table 2
Descriptive Statistics of the Routines Questionnaire and the Analysis of Invariance of the SDA-M Results with Critical Invariance Level $\lambda_{crit} = .68$

	Invariance to the experts' mental representation	RQ-Use		RQ-Development		RQ-Integration	
		M	*SD*	*M*	*SD*	*M*	*SD*
Non-Selected Players	.69	4.28	0.68	3.21	.45	2.84	0.89
Outside Hitters	.69	4.51	0.63	3.5	0.37	2.93	0.84
Setters	.73	4.2	0.53	3.24	0.51	2.76	0.88
Middle	.57	4.13	0.87	3.15	0.47	2,85	0.92
Selected Players	.86	4.26	0.64	3.22	0.40	3.05	0.75
Outside Hitters	.82	4.61	0.24	3.25	0.47	3.20	0.73
Setters	.82	4.06	0.42	3.06	0.24	2.69	0.83
Middle	.75	3.88	1.03	3.31	0.43	2.88	0.75

as a time-limited and semi-closed game skill that contains both of these routine variations. Well-structured performance routines enhanced performance outcomes and supported movement stability (Lidor, 2009), whereas removing pre-performance routines resulted in a performance decline (Foster, Weigand, & Baines, 2006). On the other hand, the use of performance routines facilitated the learning process and supported skill acquisition (Wrisberg & Pein, 1992). However, how are performance routines represented in long-term memory and how is this storage associated to the athletes' performance?

This study supported existing research and introduced an innovative method to capture cognitive and behavioral routines (i.e., tree-like representation) in a quantifiable form. Volleyball players who maintained a skillful service elicited a qualitative mental representation of the serve routine, which were similar to the routine experts portrayed. Traditionally, the measurement of movement mental representation via the SDA-M method was solely based on the movement characteristic cues (BACs). Findings in other sports, such as gymnastics, soccer, classical dance, and golf, delineated the qualitative structural differences of the movement mental representations among athletes of varying skill levels (Bläsing et al., 2009; Schack, 2003, 2004; Schack & Bar-Eli, 2007; Schack & Hackfort, 2007). Nevertheless, in the present study it has been shown that SDA-M can be used to define pre-performance routines associated with different movement phases stored in long-term memory, and represent them symbolically.

Collaboration among sport psychologists, coaches, and athletes in the preparation of the BAC pool allowed for a comprehensive data collection. Furthermore, the SDA-M method can support coaches and sport psychologists by providing a reliable and easy-to-produce image of the service routine for the purpose of diagnosis, prognosis, and correctives. The use and integration of cognitive and behavioral routines can be analyzed, viewed, and compared in an experimental setting with a reduced administration time usually needed for performance observation or interviewing methods.

As expected, the performance ranking of the coach was significantly related to the quality of the mental representations; a finding reported previously in sport setting (Heinen, 2005; Schack, 2004). Additionally, players highly qualified in the serve skill posses a similar mental representation to experts' postulation of the skill. A differentiated comparison of the SDA-M results in-between the players demonstrated the differences, which are related to the players' respective position. In comparison to the middle blockers, the structure of the mental representations of setters and outside hitters was more similar to the experts' reference structure. To account for these differences, the role of each playing position must be taken into account. The middle blockers are known as being the "jumpers" or the "team-workers." They usually play only on offense and are immediately replaced after serving from the libero position. This explains, at least in part, the reason for setters' and outside hitters' increased game involvement and more ball contacts during a game than the middle blockers (Papageorgiou & Spitzley, 2003). This infers that both setters and outside hitters must use regulative strategies during the entire game, and therefore they are more familiar with the application of performance routines in comparison to the middle blockers.

Contrary to the analysis of routine representations, the results of the RQ indicated that players of various skill use performance strategies with the same frequency. It seems that all players share similar needs for learning new cognitive or behavioral strategies, and seek to integrate the routines into their training. However, their routines reflected by their mental representations are not well-integrated into the movement processes. This inaccurate routines' integration projects itself in their performance, as the quality of their mental schemas matches their skill ranking by their coach.

According to Schack and Hackfort (2007), measuring movement representation is a vital precondition for technical preparation and consulting. We recommend that the evaluation of the routines' integration should be used in a systematic way by coaches and sport psychology consultants to stabilize or improve athletes' performances. Corresponding to our results, the practitioners should prefer the SDA-M method rather than other instruments. SDA-M provides direct information about the functional and temporal integration of the routines into movements, and its application is time-saving compared to traditional evaluation procedures. Sport psychologists can use the analysis of athletes' mental representation as basis for the compilation of mental training (e.g. imagery), to control the learning process or to evaluate the effects of a sport psychological intervention. Additionally, the SDA-M method can be considered as vital for other sports because it allows insights into the mental structure of technical and tactical skills (with or without routines) of individual players or teams. The SDA-M also allows the assessment of group structure in terms of a more detailed sociometric analysis. SDA-M can be easily applied by the practitioners and the only condition to work with it is the creation of a sport-specific pool of BACs.

Considering the meaningful match between mental representations and performance, future investigations should be undertaken with three specific aims in mind. First, sport scientists should make an effort to verify which routine learning strategies facilitate the development and restructuring of the movement mental representations, leading to significant changes in the movement outcome. Second, scientific effort must be devoted to integrate the results with qualitative reports, as well as a quantitative movement analysis. Finally, effort must be invested to clarify how the measuring of the mental representations should be used for designing individual interventions in the form of routine scripts. Imagery and instructional training (routine demand) are the two methods, which can be used for learning or optimizing performance routines.

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