THE RELATIONSHIP BETWEEN QUANTITY AND LEVEL OF COMPETITION, AND COGNITIVE EXPERTISE IN SPANISH TENNIS PLAYERS

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Original scientific paper
UDC: 796.342:796.092.298(460)

Abstract:

This work evaluates the relationship between *quantity* and *level of competition,* and cognitive expertise. To this end, cognitive expertise has been evaluated in Spanish tennis players (N=150) by means of declarative knowledge (DK) and procedural knowledge (PK) levels. DK and PK were assessed through a specific questionnaire (DK/PK-QT; García-González, Moreno, Moreno, Iglesias, & Del Villar, 2008). ANOVAs showed significant differences in both DK and PK with regard to the *quantity of competitions* played ($F(2, 147)=23.28$; $p<.001$; $\eta_p^2=.24$ for DK; $F(2,147)=44.52$; $p<.001$; $\eta_p^2=.37$ for PK) and with regard to the *level of competition* ($F(2, 147)=20.91$; $p<.001$; $\eta_p^2=.22$ for DK; $F(2, 147)=37.59$; $p<.001$; $\eta_p^2=.34$ for PK). Furthermore, the Spearman's Rho test showed that DK and PK were strongly correlated to *quantity* and *level of competition*. These results suggest that *quantity* and *level of competition* could be of central importance for the development of expertise in tennis players. In sport training stages, we recommend coaches to plan participation in competitions (in the short and medium term), so that competitions would provide appropriate and significant experiences in real setting conditions (i.e. they should be ecologically valid). These competitions must be high-level ones and sufficiently challenging so as to foster the development of cognitive expertise. Competitive structures (e.g. season competitions), which favor cognitive elements (e.g. DK and PK) and develop expertise in athletes, will also have to be put into practice.

Key words: *sport expertise, match-play, competition level, tennis*

Introduction

Numerous studies can be found in the field of expert performance that underscore the influence of cognitive factors (e.g. knowledge, memory structures, decision-making, etc.) on sport expertise (see Williams & Ericsson, 2005, for a review). Furthermore, the embodied cognition rationale sets out that these cognitive factors will interact with other typical elements of the athlete, of the environment and of the athletes' own actions (Beilock, 2008). In this regard, the so-called cognitive expertise of athletes is determined by different factors, such as visual behavior, decision-making and other variables related to long-term memory; however, it is also constrained by the environment (MacMahon & McPherson, 2009).

Cognitive psychology, through the expert-novice paradigm, explains that the advantage of expert athletes depends mainly on internal mental representations and on cognitive processes that mediate between stimulus interpretation and action selection (Hodges, Starkes, & MacMahon, 2006). The following cognitive characteristics can be found in expert athletes: greater knowledge of actions that are more likely to occur; greater, more organized and structured declarative knowledge (DK) and procedural knowledge (PK); more efficient storage of and access to information in their memories (Moran, 2004; Ruiz, Sanchez, Durán, & Jimenez, 2006; Wrisberg, 2001). Within cognitive psychology, the Adaptive Control of Thought--Rational (ACT–R) theory (Anderson, Bothell, Byrne, Douglas, Lebiere, & Quin, 2004) establishes two types of knowledge: DK and PK. DK is identified with *know what* or *what to do* and refers to the knowledge of the rules and objectives of the game (Anderson, 1987; McPherson, 1994; Thomas, 1994), whereas PK is identified with *know how* or *doing* *it* and is defined as a response-selection procedure (Abernethy, Farrow, & Berry, 2003; Anderson, 1987).

Other cognitive variables, such as decision-making, are influenced by knowledge in sport settings. Decision-making is a core process in sport, which is influenced by the athlete's limited knowledge (i.e. knowledge structures stored in the memory directly condition and influence decision-making; Köppen & Raab, 2009). The greater and the more varied this knowledge, the better the decisions made by the athletes and the higher level of the expertise will be achieved (McPherson & Thomas, 1989; Starkes, Helsen, & Jack, 2002; Williams & Davids, 1995; Williams, Davids, & Williams, 1999). Furthermore, knowledge has influence on other cognitive processes in tennis players, such as directing attention, visual behavior, anticipation, as well as response selection, and execution or performance. Likewise, the knowledge accessed and the use of strategies and tactics by tennis players will depend on the context determined by the environment, the athlete and the task (MacMahon & McPherson, 2009).

Based on the psychological characteristics of an expert athlete, we can ask the following question: what factors are needed to achieve expert performance? And also, what should we do to develop cognitive expertise in sport? There are primary influences on expertise that include genetic, training and psychological factors, which determine the acquisition and development of high-performance levels (Baker & Horton, 2004). Training-related factors are variables that have traditionally stood out when determining the direct relationship between practice (i.e. type and time of practice and training) and performance (Baker & Horton, 2004). Research gives us theoretical bases that range from the Deliberate Practice Theory (Ericsson, Krampe, & Tesch-Römer, 1993), to sport development models (see Côté, Baker, & Abernethy, 2003, for a review).

Deliberate practice theory assumptions (Ericsson, et al., 1993) highlight the need for a long period of intense and focused practice before achieving elite performance, with practice specifically focused on performance improvement (Ericsson, 2008). With these requirements, intensive training would be necessary prior to expertise, with an important relationship between practice and performance (Abernethy, Côté, & Baker, 2002; Ward, Hodges, Williams, & Starkes, 2004). Some critics of these theories state that they do not study the specific characteristics of practice or its micro-structure, as the best types of practice to achieve performance has not been established (Davids & Baker, 2007). Based on that idea, it has been shown that some activities are essential in order to achieve performance and expertise in sport (e.g. video training, competition participation or individual activities and instructions like specific and individualized decision-training; Baker, Côté, & Abernethy, 2003; Deakin & Cobley, 2003). Maybe due to these types of activity, the relationship between the amount of practice and performance is not as linear as initially formulated in the theory of deliberate practice (Baker, Côté, & Deakin, 2005; Ward, et al., 2004). One of the elements that must be taken into account is the quantity of competitions that participants take part in, as sport-specific activities. This is because there are approaches that either support the need to accumulate experience in competition situations, or that demand performance to contribute to improving the level of expertise (Reid, Crespo, Santilli, Miley, & Dimmock, 2007; Ward, Hodges, Starkes, & Williams, 2007).

Very few studies have been found that evaluate the relationship between competition (e.g. its quantity, type, quality) and cognitive expertise, and the use of these variables to study sport expertise is limited (e.g. García-López, Guitiérrez, Abellan, González-Villora, & Webb, 2010; Elferink-Gemser, Kannekens, Lyons, Tromp, & Visscher, 2010). Baker and colleagues (2003) establish the need to study the benefits of competition participation, because they have not been included in the studies of deliberate practice theory, probably because competitive activity has not been included within the initial concept of deliberate practice. This theory has eliminated competition participation as a discriminating factor in sport expertise acquisition, despite the fact that competitive activities provide greater practice and performance specificity (Berry, Abernethy, & Côté, 2008). Our study aims to provide evidence of the relationship between participation in competitions and cognitive expertise.

Some studies indicate that time spent on competition and match-play is a basic factor in expertise development, and that it favors the development of cognitive skills. Competition has also been identified by expert athletes as the most useful activity to develop perceptive-decision skills (Baker, et al., 2003; Berry, et al., 2008; MacMahon, Helsen, Starkes, & Weston, 2007). In terms of cognitive variables (i.e. DK, PK, decision-making, etc.), some studies show that those athletes who accumulated a greater number of hours of experience in structured activities are better at decision-making (Berry, et al., 2008; Berry & Abernethy, 2009), highlighting the importance of providing different types of activities to develop cognitive expertise. More specifically in tennis, competition and competitive match-play is a key factor for the successful development of a player, because it enables developing performance-related skills (Crespo, Reid, Miley, & Atienza, 2003; Reid, et al., 2007; Reid, Crespo, & Santilli, 2009). Furthermore, time and the number of competitions are not the only relevant factors in developing expertise since the level of competitions has also been identified as a factor that may contribute to the development of cognitive expertise in intermediate-level tennis players (Côté, Ericsson, & Law, 2005; Crespo, et al., 2003).

The aim of our study was to assess how the quantity and level of competitions, which athletes take part in, can be related to the development of their cognitive expertise. With regard to the objective of the study, and based on the importance of competition, explained previously, we put forward two hypotheses: i) that tennis players who participate in a larger number of competitions will have a higher level of cognitive expertise and ii) that players who participate in higher-level competitions will have a higher level of cognitive expertise.

Methods

Participants

The sample was comprised of 150 Spanish tennis players (male=84; female=66), who were in their formative stages and who regularly participated in local, regional and/or national competitions.

The requirements for sample selection were a minimum of one year engagement in the sport and a minimum of one year competition. Players' ages varied between 10 and 16 years (M=13.07; SD=1.63), their experience in terms of time playing tennis was between one and 10 years (M=6.08; SD=2.27) and their experience in tennis competitions was between one and eight years (M=3.73; SD=1.89). All players were classified by the International Tennis Number (ITN), developed by the International Tennis Federation (ITF), between levels five and seven, defined as Intermediate players (ITF, 2004). The level distribution of participants was as follows: 47 players at level five, 52 players at level six and 51 players at level seven. All participants were right-handed tennis players because the questionnaires were limited to right-handed tennis players.

To ensure that the players' level was really similar and that the ITN level was not a contaminating variable of the study, a preliminary analysis of differences (ANOVA) was performed, comparing the level of PK and DK in agreement with the ITN level. No significant differences were found between the various ITN levels either in PK ($F(2, 147)=0.080$; $p=.923$), or in DK ($F(2, 14)=0.036$; $p=.965$), so the sample of participants was considered homogenous.

Procedures

Declarative knowledge (DK) and procedural knowledge (PK) were dependent variables in our research. DK is identified as *what to do* (Anderson, 1987; McPherson, 1994; Thomas, 1994) and PK as *doing it* (Anderson, 1987; Thomas, 1994).

The aim of the independent variables assessed was to describe the tennis players' competition characteristics during the previous year. To do so, the variable of *quantity of competitions* was used, considering the amount of competitions played during the previous year. These were distributed into three levels: Level one – from one to nine tournaments, included 68 players; Level two – from 10 to 15 tournaments, included 39 players; and Level three – more than 15 tournaments, included 43 players. The average number of competitions was 10.85 (SD=6.57). The three levels of *quantity of competitions* were established via an expert validity procedure, with the participation of three expert coaches (coaches of expert players in the National Federation with more than 10 years of experience), and two researchers (experts in research methodology with experience in tennis research studies).

The other variable describing competition was *level of competition*, which refers to the competition level of the tournaments played. In this regard, there were three groups: Local (included 67 players), Regional (included 52 players) and National (included 31 players). Every participant was classified in only one single *level of competition* according to the most common level of competitions he/she participated in during the previous year (e.g. if a player had played in two regional tournaments and six national tournaments, he/she was classified at *national level*). If the participant had played in the same number of tournaments at different levels, he/she was classified at the higher level (e.g. if a player had played five regional tournaments and five national tournaments, he/she was classified at *national level*).

Two questionnaires were used to assess DK and PK in tennis. They were adapted from the original by McGee and Farrow (1987). Validation of both questionnaires resulted in the final versions comprising 23 questions for every questionnaire (DK/PK-QT; García-González, Moreno, Moreno, Iglesias, & Del Villar, 2008) with suitable levels of validity and reliability. Internal consistency values of above .70 were obtained by Cronbach's alpha (Nunnally, 1978). The questionnaires were written for and the questions were posed referring to the right-handed tennis players. Every question had one single correct answer out of a multiple choice of four options. These questionnaires have been used in other research studies to evaluate cognitive expertise at different expertise levels (García-González, et al., 2008; García-González, Moreno, Moreno, Iglesias, & Del Villar, 2009; García-González, Iglesias, Moreno, Gil, & Del Villar, 2011).

The DK questionnaire was arranged into four blocks in agreement with the original one: technique, rules, general knowledge and general tactics, with five or six items per block. An example of a DK question was: As a general rule, where should you stand to return serve in the deuce court? a) near the right-hand corner of the court; b) in the middle of the court; c) in the tramlines; d) in the middle between the center line and the side line (the correct answer should be a). The PK questionnaire was based on the tactical section of the original questionnaire. It included questions about the different tactical situations or game phases in tennis: serve, return, baseline play, baseline player against the opponent at the net, and net player against the baseline opponent player. An example of a PK question was: You are displaced to the back right-hand side of the court to hit the ball. What stroke should you play to gain time and be ready for your opponent's next stroke? a) deep crosscourt forehand; b) deep groundstroke; c) short crosscourt forehand; d) lob to the middle of the court (the correct answer should be a).

The level of knowledge was evaluated by means of the number of right answers in every questionnaire over the maximum of 23 correct answers in each questionnaire.

Both questionnaires were presented in the same document. Independent variables were recorded on the initial sheet of paper with the descriptive details of age and experience.

Data collection was done in a closed room after a training session. Participants and parents signed an informed consent as required by the Helsinki Declaration (2008) and the local ethics committee. There were no technical problems during data collection. The data were collected and used exclusively for the objectives of the study.

Statistical analysis

The SPSS 17.0 statistical program was used to analyze data. Firstly, a data distribution normality analysis was conducted. The measures of skewness, kurtosis, and Kolmogorov-Smirnov test with Lilliefors correction showed a normal distribution of data, thus allowing the use of parametric statistics.

Descriptive statistics of variables was based on means and standard deviations; an inferential analysis was performed by a one-way ANOVA and Tukey's HSD *post-hoc* test. The effect size (ES) was also calculated by means of partial eta-squared (η_p^2) to establish the extent of the differences found, because this analysis eliminates the influence of sample size. The power of the test was also calculated through statistical power (SP=1-β).

An additional correlation analysis was also performed to analyze the relationship between the dependent and independent variables of the study by calculating Spearman's Rho correlation coefficient, because the independent variables were ordinal and categorical. The level of statistical significance used was set at $\alpha<.05$.

Results

In connection with the independent variable *quantity of competitions,* it could be seen how the DK and PK levels increase according to the number of competitions. There were significant differences between the different levels of the *quantity of competitions* variable both in DK and PK (Table 1) with a high effect size (Maroco, 2011).

Tukey's HSD *post-hoc* test (Table 2) showed that there were significant differences among all levels of *quantity of competitions* in both the DK and PK of tennis players.

Table 1. Descriptive and inferential statistics for both DK and PK according to the quantity of competition

	Quantity of competition	M±SD	$F_{(2,147)}$	p	ES (η_p^2)	SP (1-β)
DK	1 to 9 tournaments	16.16±3.38	23.278	<.001	.241	1.000
	10 to 15 tournaments	17.88±2.25				
	>15 tournaments	20.03±1.87				
PK	1 to 9 tournaments	11.37±3.24	44.523	<.001	.377	1.000
	10 to 15 tournaments	13.41±2.66				
	>15 tournaments	16.92±2.43				

ES=effect size; SP=statistical power; DK=declarative knowledge; PK=procedural knowledge

Table 2. Tukey's HSD post-hoc test for DK and PK according to the quantity of competition

	(A) Quantity of competition	(B) Quantity of competition	Mean differences (A - B)	Typical error	p
DK	1 to 9 tournaments	10 to 15 tournaments	-1.716	.597	.013
	1 to 9 tournaments	>15 tournaments	-3.869	.573	<.001
	10 to 15 tournaments	>15 tournaments	-2.153	.696	.007
PK	1 to 9 tournaments	10 to 15 tournaments	-2.040	.614	.003
	1 to 9 tournaments	>15 tournaments	-5.551	.589	<.001
	10 to 15 tournaments	>15 tournaments	-3.510	.716	<.001

DK=declarative knowledge; PK=procedural knowledge

Table 3. Descriptive and inferential statistics for DK and PK according to the level of competition

	Level of competition	M±SD	$F_{(2,147)}$	p	ES (η_p^2)	SP (1-β)
DK	Local	15.95±3.43	20.911	<.001	.221	1.000
	Regional	18.57±2.28				
	National	20.06±2.21				
PK	Local	11.22±3.42	37.586	<.001	.338	1.000
	Regional	14.18±2.68				
	National	17.88±2.36				

ES=effect size; SP=statistical power; DK=declarative knowledge; PK=procedural knowledge

Table 4. Tukey's HSD post-hoc test for DK and PK according to level of competition

	(A) Level of competition	(B) Level of competition	Mean differences (A - B)	Typical error	p
DK	Local	Regional	-2.629	.503	<.001
	Local	National	-4.117	.800	<.001
	Regional	National	-1.489	.814	.164
PK	Local	Regional	-2.961	.527	<.001
	Local	National	-6.656	.839	<.001
	Regional	National	-3.695	.853	<.001

DK=declarative knowledge; PK=procedural knowledge

There was also a positive and significant correlation between the *quantity of competitions* and DK (Spearman's Rho=.507; p<.001), as well as between the *quantity of competitions* and PK (Spearman's Rho=.607; p<.001)

As for the *level of competition* variable, DK and PK increased as the level of the competitions played increased. There were significant differences in DK and PK depending on the *level of competition* (Table 3) with a high effect size (Maroco, 2011).

Tukey's HSD *post-hoc* test (Table 4) showed significant differences in DK between those players competing at a local and regional level, and those who played mostly at local and national tournaments. However, there were no significant differences between regional and national levels for DK. With respect to PK, there were significant differences among all *levels of competition*.

There was also a positive and significant correlation between the *level of competitions* and DK (Spearman's Rho=.483; p<.001), as well as between the *level of competitions* and PK (Spearman's Rho=.565; p<.001).

Discussion and conclusions

The aim of this research was to study cognitive expertise in tennis players in relation to the quantity and level of the competitions played. The first hypothesis suggested that tennis players participating in a greater number of competitions would have a higher level of cognitive expertise and this hypothesis was confirmed. We found significant differences in DK and PK between the different levels of *quantity of competition*. Furthermore, the relationship between *quantity of competitions* and the level of DK and PK proved to be important in the intermediate athletes included in our study. These results indicate that tennis players taking part in a greater number of competitions came closer to the expert knowledge profile, with a higher DK and PK (Moran, 2004). Expertise is the result of the development of specific knowledge and skill structures through a practice adaptation process, where, among other aspects, specific practice (e.g. competitions) plays an essential role (Ericsson, 2003). Participation in competition brings players closer to an expert knowledge profile, developing more specific procedures applicable to game situations (McPherson & Thomas, 1989). This shows how *doing* helps *knowing* (Williams & Davids, 1995).

Consequently, it can be interpreted that competition is a basic activity for expert performance (Baker, et al., 2003), and also for the development of cognitive expertise. Furthermore, as indicated by Reid and colleagues, experience in competition or match-play is a performance predictor (Reid, et al., 2007). Participation in competition has also proven, in other studies, to be one of the activities that favors the development of skills (Baker, et al., 2003; Ward, et al., 2007). The same occurs with the number of competition opportunities, because some studies have indicated that competition opportunities can determine the development of tennis players in a specific way (Crespo, et al., 2003). So, it could be suggested that competition in tennis is an important factor for tennis players' cognitive development (Crespo, Miley, & Couraud, 2001; Reid, et al., 2007). The necessity to participate in competitions is also justified by their nature since match-playing is the most specific activity which enables players to implement their achieved skills, thus becoming one of the best examples of deliberate practice (Berry, et al., 2008).

The second hypothesis suggested that cognitive expertise of players participating in higher--level competitions would develop greater. This hypothesis was also confirmed. Our results showed significant differences in cognitive expertise, both in DK and in PK, between the levels of competition. The relationship between *level of competitions* and the level of DK and PK was also important in the intermediate tennis players of our study. This indicates that there is an important relationship between level of competitions played and the development of knowledge in tennis players. As stated previously, competition is a basic activity for expert performance (Baker, et al., 2003) and it is important to provide athletes with opportunities to compete, understanding competition participation as a formative activity, regardless of the result accomplished (Berry, et al., 2008). The level of competition is also important for the player's development (Crespo, et al., 2003). Several advantages may arise as a result of extended engagement in sport-specific play activity, where and when participants are allowed to experiment with different skills, techniques and tactics within their sport. Such conditions create the opportunity to innovate, improvise, and respond strategically, recreating those conditions that are important at elite level (Williams, Ford, Eccles, & Ward, 2011).

Although research into the competition level or quality of competition is limited, relationships between the competition level and PK can be found and they back up the results of our study. A study on soccer (García-López, et al., 2010) showed that the athletes participating in national and international competitions had a significantly higher level of PK than those athletes who participated in regional or lower-level competitions. The same occurred with tennis players in our study. Likewise, another study (Elferink-Gemser, et al., 2010) found significant differences in PK and DK among athletes who participated in competitions at different levels. That is why it is necessary to highlight the need to facilitate participation of young players in suitable and significant experiences at a high performance level that are sufficiently challenging (Berry, et al., 2008). Experience developed in competition or in similar activities (e.g. game play training) may predict performance levels (Reid, et al., 2007).

On the other hand, there were significant differences in PK between the three levels of competition established in our study. But this did not occur in DK, where there were no differences between regional and national levels. Absence of differences in DK between all levels of competition may be the result of different characteristics of types of knowledge, where DK (i.e. *what to do*) is more related to general rules and tactics, but is less directly related to game actions (i.e. shot decision--making) than PK (i.e. *doing it*) (Abernethy, et al., 2003; McPherson, 1994). These aspects were also confirmed by correlation analysis results of our study, where the correlation of quantity and level of competitions was greater with PK than with DK.

Although level of competition is important to the development of DK levels, in our study this knowledge did not significantly increase from a regional level onwards. This may be due to the fact that DK is more important at lower performance stages since it is the base for constructing future PK (Anderson, et al., 2004). On the other hand, the direct link between competition level and PK (i.e. *doing it* specifically related to the game process) may establish more differences between competition levels, so PK is more necessary for decision-making at higher performance stages. These aspects should be taken into account by coaches when they develop training sessions and design tasks, as well as during their instruction and intervention with players (e.g. carrying out training activities that have the same requirements as real competitions, or proposing conditioned competitive activities).

However, despite the established benefits of the participation in competitions, we must be aware of other possible consequences. In accordance with some of the most outstanding theories related to sport motivation (i.e. achievement goal theory – Nicholls, 1989; and self-determination theory – Ryan & Deci, 2002), we must take full account of the fact that competition may also have negative consequences. If competition only addresses athletes' performance, as an exclusively ego-oriented climate in this type of activities (i.e. evaluating competition only in terms of victory or defeat with respect to the opponent), it may generate decreased learning, or amotivation in the athlete and even abandonment (Balaguer, Duda, & Crespo, 1999; Vallerand, 2007).

Finally, we must take some limitations of this study into account. Firstly, despite having found differences in cognitive expertise depending on the quantity and level of competitions, we must bear in mind that these are not the only variables that may have an influence. There are many different factors that affect the development of expertise, either related to engagement in the sport and competition or else related to genetic or psychological factors (Baker & Horton, 2004). Thus, studies will have to be conducted that will enable assessing the influence of other variables. In this regard, the variables of age and experience in engagement and competition should be controlled in future studies in order to control their possible effect. Studies would also be necessary to help discover how the variables of *quantity* and *level of competition* can influence the development of players, and how the planning of these variables should be taken into account.

The main conclusion drawn from this study is that competition could be an important environment to develop cognitive expertise in athletes. Quantity and level of competition are specific variables that must be considered and handled by coaches in the sport-planning process, both in the short term (e.g. planning quantity and level of competitions within a sports season), and in the medium to long term (e.g. planning how the quantity of competitions is going to evolve over several seasons, planning the level of difficulty/quality of the competitions for the players in the coming year) during athletes' different performance stages.

Likewise, the relationship between participation in competition (quantity and level) and level of expertise suggests the need to promote competition as a learning activity from the initial formative stages of athletes. Therefore, coaches should develop competitive structures, i.e. plan competitive activities like tournaments and leagues, and distribute them within the season calendar and promote regular competition. These competitions must be understood as a learning means and not a way of achieving a better classification; the final result must not be the only decisive factor.

This competitive structure must adapt the quantity and level of competition to the athletes' level of expertise, so that athletes can progressively participate in ever more competitions of a progressively higher standard. The organization of competitions by clubs and federations should control these variables to favor athletes' learning and development, e.g. developing a more extensive calendar for each season; reducing participation limitations in tournaments; organizing weekly or regular competitive structures, such as leagues, and others.

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Submitted: November 3, 2014
Accepted: February 12, 2015

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