On the Characteristics of On-the-Spot Tactical Decision Making and Cognitive Mechanism in Tennis Teaching

Xin Wang, Yuanguo Liu*

ABSTRACT

Tennis is a skill-oriented antagonistic net-separating sport. It requires players to change speed and give responses very quickly and make accurate judgments and decisions on the path of the ball. Based on electroencephalography (EEG), this paper assigns general-situation and specific-situation decision making tasks to tennis players and college students, and analyzes the cognitive mechanisms of tennis players. The experimental results show that: college students' decision-making response time was obviously longer than that of the player group, and that the decision scores and accuracy of the player group were significantly higher than those of the college student group. After specialized training, tennis players had intuitions when making decisions. Their intuitive decision-making abilities were much stronger than those of the college student group. Due to the spatial positioning or stimulatory interference suppression effects of the players' brains, stimulus conditions induced P1 and P2 waveforms, and with the peak amplitude increasing and the latency period becoming longer, such phenomena of the player group were increasingly obvious.

Key Words: Tennis Sport, Sports Decision-making, EEG, Specific-situation Decision Making, Peak Amplitude

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Introduction

Modern tennis sport originated in the United Kingdom and developed in France. After experiencing the propagation, development, comprehensive improvement and innovation periods, it has now become a world-wide sport aiming at being "higher, faster, more complete, more accurate and speed-changing" (Elamvazuthi *et al.*, 2015; Konukman *et al.*, 2010). On the tennis court, we often see the beautiful drives, chops, volleys and smashes of professional tennis players (Pereira *et al.*, 2018; Galewatts and Nevill, 2016). Whenever a player hits the ball into the opponent's court quickly, accurately, and swiftly, we not only are amazed by his or her excellent physical conditions and outstanding skills, but also think about how he or she can accurately seize the moment and control the rapid changes on the fierce and rapidly changing field (Seferoğlu *et al.*, 2013). Therefore, tennis players must have not only excellent physical conditions, mental quality, and playing skills, but also quick response and positioning abilities, so as to adjust their positions on the court at any time (Ohayon *et al.*, 2013; Ishihara *et al.*, 2017).

In the fast-changing tennis teaching match, players need to judge and analyze the situation on the court, make decisions and then make appropriate technical moves (Ishihara *et al.*, 2017). Currently, there are many problems that are puzzling sports psychologists. What are the differences in the brain nervous processes between professional tennis players and ordinary people? Is there any difference between tennis

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players of different levels? Do players acquire the decision-making abilities through training (Barber-Westin *et al.*, 2010; Girard *et al.*, 2011). With the rapid development of EEG, cognitive science technologies are used to study the cognitive characteristics of tennis players and reveal the changes in their neural mechanisms on tennis courts, which provide important experimental basis for the psychological studies on tennis sports in the future (Smolianov *et al.*, 2014). This paper adopts the ERP method and uses pictures of tennis teaching match as stimulus materials to study the sports decision-making behaviours and cognitive mechanisms of tennis players and ordinary college students.

Characteristics of general-situation decision making

Experimental method

On the tennis court, players' decision-making abilities are very important. Players need to make accurate judgments on the direction and speed of the ball, as this is very important for their performance on the court (Gomes *et al.*, 2014). Such decision-making abilities, built on the automated procedural movement techniques, are highly flexible and autonomous (Pereira *et al.*, 2015; Fernandezfernandez *et al.*, 2016). In general, the faster a tennis player makes a decision, the shorter time it takes to activate the brain and the more psychological resources it consumes (Rui *et al.*, 2017). In this paper, the author recruited 30 college professional tennis players majoring in tennis and 30 non-sport-major college students (without systematic tennis training) on a paid basis to discuss the decision-making characteristics of different groups after they saw pictures of basketball teaching match. A subject would get 1 point if he or she made the correct decision based on the picture, and 0 point for the wrong decision. The time it took each subject to respond to each picture was recorded as the decision response time. The author selected 100 pictures in total for the experiment and acquired data using the software E-Prime. The accuracy and response time of the subjects were subject to repeated ANOVA SPAA17.0 by the statistical software package SPAA17.0.

Analysis of experimental results

Table 1 lists the decision scores and accuracy of the professional players and the college students. Figure 1 compares the decision scores and accuracy of the players and the college students. According to the results, the decision scores of the players and the college students were 53.422 and 53.240 and their accuracy was 67.108 and 67.008, respectively, showing no significant differences. Table 2 shows the repeated ANOVA results of the decision scores and accuracy of the player group and the college student group with respect to different types of pictures. It can be clearly seen that there was no significant interaction between the groups and the picture types, but that the scores with respect to the two types of pictures differed significantly. The scores of the subjects with respect to disparate pictures were obviously lower than those with respect to similar pictures. Table 3 shows the statistical results of the decision response time and the correct decision response time of the players and the college students. The shorter the response time, the faster the response of the subject, and the stronger the on-the-spot tactical decision-making ability. As can be seen from the table, there were little differences in the response time and correct response time between the college student group and the player group. Figure 2 shows compares the response time and correct response time of the player group and the college student group. It can be seen that the correct response time of the college student group was slightly longer. Table 4 shows the repeated ANOVA results of the correct response time of the player group and the college student group with respect to different types of pictures. It can be seen that there was no significant interaction between the picture types and the groups. The correct response time of the two groups with respect to similar pictures was shorter than that with respect to disparate ones, and the decision scores with respect to the two types of pictures were significantly different. Through the research in this section, it is found that the special decision-making abilities of high-performance professional tennis players cannot be transferred to daily life.

Table 1. Decision scores and accuracy of the player group and the college student group

Group	Index	M	SD
Player group n=30	Decision score	53.422	5.876
	Decision accuracy/%	67.108	7.335
College student group n=30	Decision score	53.240	5.703
	Decision accuracy/%	67.008	6.282

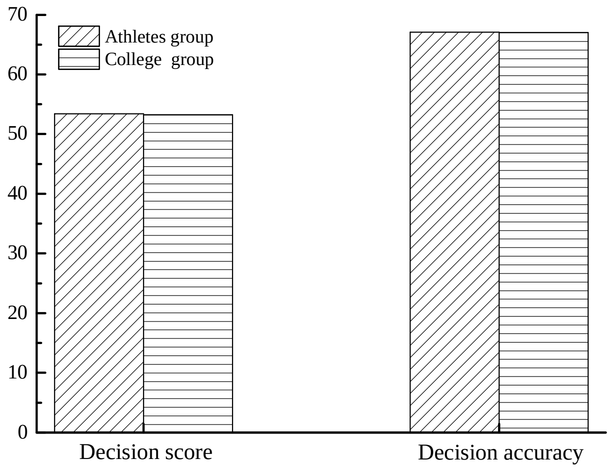

Figure 1. Comparison of the decision scores and accuracy rates between players and college students

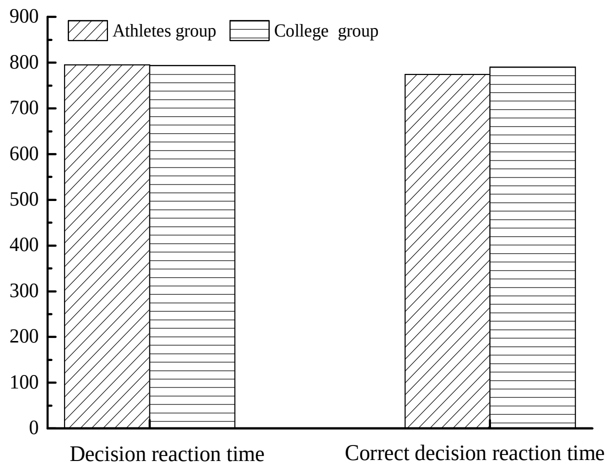

Figure 2. Comparison of the decision response time and the correct decision response time between the player group and the college student group

Table 2. Repeated ANOVA results of the decision scores and accuracy rates of the player group and the college student group with respect to different types of pictures

Picture type	Group	Index	M	SD	Group effect	
					F	P
Similar pictures	Player group	Decision score	32.822	3.512	0.000	0.637
		Accuracy/%	81.222	9.047		
	College student group	Decision score	32.140	4.183		
		Accuracy/%	79.514	10.624		
Disparate pictures	Player group	Decision score	21.5	6.075	2.566	0.830
		Accuracy/%	53	15.104		
	College student group	Decision score	21	4.4		
		Accuracy/%	54	11.14		
Picture type					62.655	0.000
Picture type*group					0.147	0.683

Table 3. Statistics of the decision response time and correct response time of the player group and the college student group

Group	Index	M	SD
Player group n=30	Decision response time	794.860	162.275
	Correct decision response time	774.262	166.373
College student group n=30	Decision response time	793.666	79.488
	Correct decision response time	790.381	89.527

Table 4. Repeated ANOVA results of the correct decision response time of the player group and the college student group with respect to different types of pictures

Picture type	Group	Index	M	SD	Group effect	
					F	P
Similar pictures	Player group	Correct response time	771.157	166.847	5.142	0.735
	College student group	Correct response time	756.072	75.330		
Disparate pictures	Player group	Correct response time	813.260	169.608	3.525	0.813
	College student group	Correct response time	808.485	98.445		
Picture type					19.888	0.000
Picture type*group					0.230	0.616

Characteristics of specific-situation decision-making and ERP study

Experimental method

In the general-situation task, tennis players did not demonstrate their outstanding sports decisions-making abilities, nor did they show much advantage in the specific cognitive features and neural mechanisms of decision making (Johns *et al.*, 2011; Buchanan and Barrow, 2016). During a tennis teaching match, there are many factors that can affect the decisions of tennis players, involving not only the processing of the physical characteristics of stimulus information, but also the endogenous cognitive processing. Compared with college students, players were faster in making specific-situation sports decisions, spent less time on activation and achieved higher accuracy. In this experiment, professional tennis players and college students were still used as subjects. The decision-making tasks were to make cognitive and intuitive decisions. A mixed experiment design was adopted to test the decision scores, accuracy, response time, correct response time and confidence levels of the subjects. The stimulus materials for the experiment were screenshots captured from videos of open tennis tournaments, including classic shots, slices and drives in tennis teaching match. The EEG test equipment was Neurone EEG/ERP system, which consists of an EEG signal amplifier (Neurone Model Black amplifier) and an EEG cap (Ag/AgCl64-lead Neurone cap), with a sampling frequency of 500Hz. The behavioural data were collected by the software E-Prime, and the EEG data were analyzed and processed by SPSS after filtering, removal of EOG and artifacts and baseline correction.

Analysis of behaviour results and EEG results

Figure 3 shows the accuracy of the player group and the college student group in making the two types of decisions. It can be seen in terms of cognitive and intuition decisions, the decision scores and accuracy of the player group were much higher than those of the college student group, and according to the repeated ANOVA results, both groups of subjects showed significant differences in decision accuracy and scores. Figure 4 compares the response time of the player group and the college student group with respect to the two types of decisions. Under the two decision making tasks, the response time of the college students (about 900ms) was significantly longer than that of the player group (about 700ms). Through repeated ANOVA, it is found that there was no significant difference in the response time for the two types of decisions.

Figure 5 shows the difference waves between the ERP average overlay waveforms of the player group and the college student group at the Fr, Cz, and Pz electrode points. The analysis focused on P1 components (60-130ms) and P2 components (130-210ms). Through the P1 component analysis, it is found that there were significant differences in the peak amplitudes of the two groups. The peak amplitudes of the college student group were higher, but under both decision making tasks, the highest peak amplitude existed in the frontal region. There was no significant interaction between brain regions, groups and task types, but there were significant interactions between brain regions and groups. The P2 component analysis finds that in terms of cognitive decisions, the peak amplitude of the player group was higher than that of the college student group, and that the peak amplitudes showed significant differences in the frontal and the top regions, but no significant difference the occipital region; in terms of intuitive decisions, the peak amplitude of the college student group was higher, and the peak amplitudes showed significant differences in all three brain regions. Through repeated ANOVA of the brain regions, it is found that the main effects of P2 peaks were not obvious in each brain region.

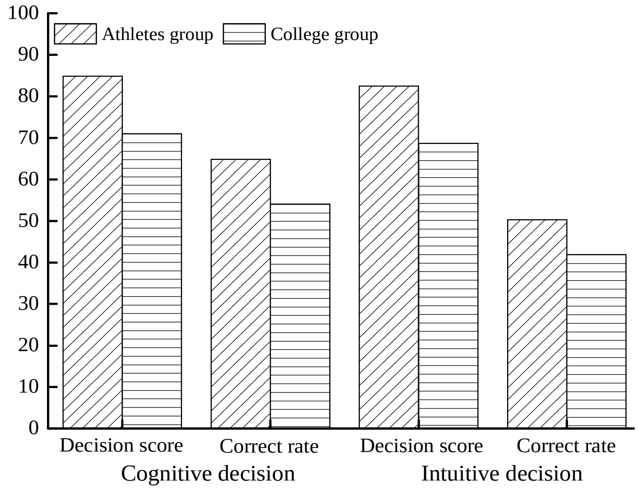

Figure 3. Accuracy of the player group and college student group for the two types of decisions

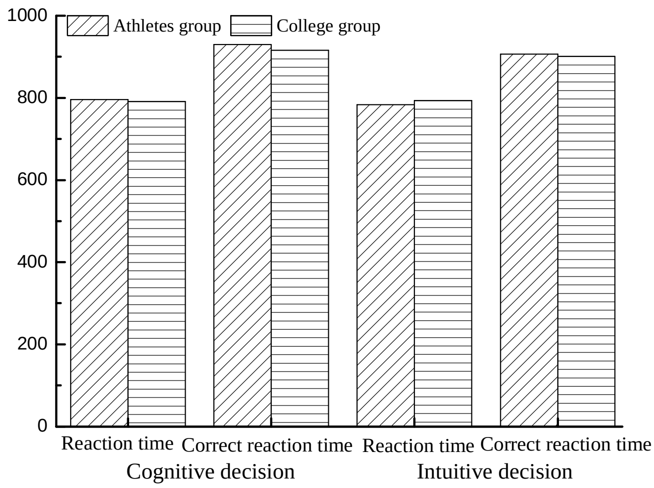

Figure 4. Comparison of the response time between the player group and college student group for the two types of decisions

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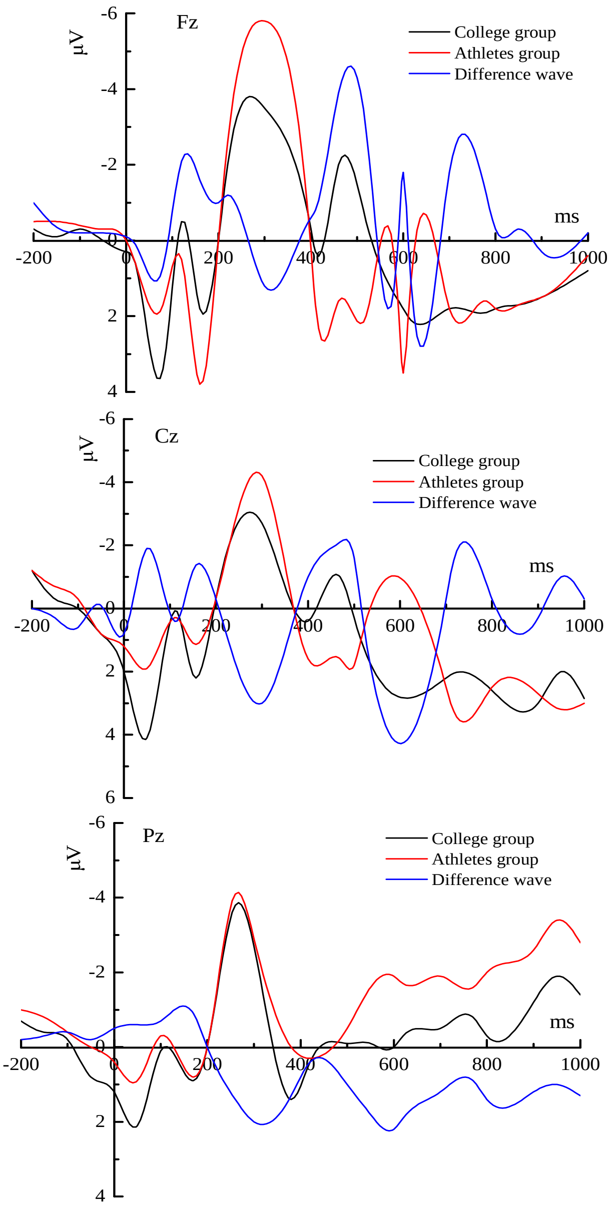

Figure 5. Difference waves of ERP average overlay waveforms between the player group and the college student group

Research on the cognitive mechanism in the tennis sport process

Comparison of peak amplitudes and latency periods under two cognitive decision-making conditions

Figure 6 shows the P1 peak amplitudes of different groups under two decision tasks. It can be clearly seen that the peak amplitudes of the player group were significantly smaller than those of the college student group with respect to both decision types. In terms of cognitive decisions, the peak amplitude of the top region was the largest. In terms of intuitive decision, the peak amplitude of the frontal region was the largest. Figure 7 compares the P1 latency periods of different groups under the two decision-making tasks. It can be seen that, under the two decision tasks, the induced p1 latency period of the college student group was significantly longer than that of the player group; difference analysis shows that there was no significant difference between the two groups of subjects in terms of the latency period in the occipital region, but that there were significant differences in the latency period in the frontal and top regions. Figure 8 shows the P2 peak amplitudes of different groups under two decision tasks. The peak amplitudes exhibited by the two groups of subjects were quite different. In the cognitive decision, the peak amplitudes showed significant differences in the frontal and top regions but no significant difference in the occipital region. In terms of intuitive decisions, the main effects of the peak amplitudes in the three brain regions showed significant differences. Figure 9 compares the P2 latency periods of different groups in different brain regions under the two decision-making tasks. Under the two decision-making conditions, there were great differences in the latency periods between the two groups. In terms of cognitive decisions, the latency period of the player group was shorter than that of the college student group, while the case is the opposite in terms of intuitive decisions. Under the cognitive decision-making condition, the latency periods of the three brain regions showed obvious differences, but under the intuitive decision-making condition, only those of the frontal and top regions showed obvious differences.

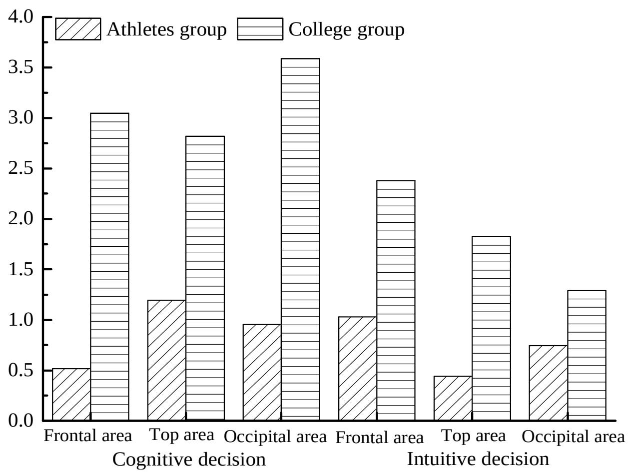

Figure 6. Comparison of P1 peak amplitudes of different groups under two decision-making tasks

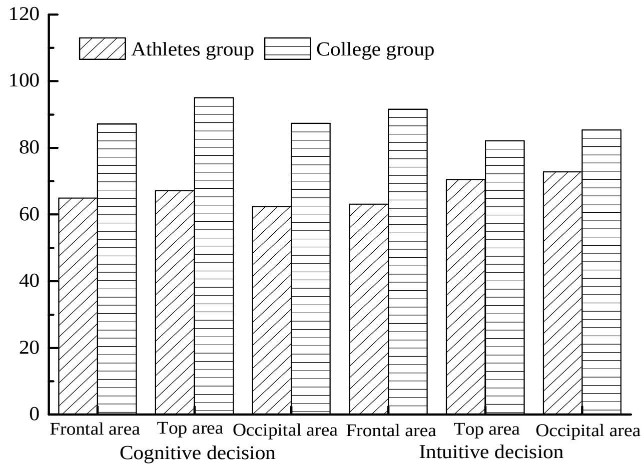

Figure 7. Comparison of P1 latency periods of different groups under two decision-making tasks

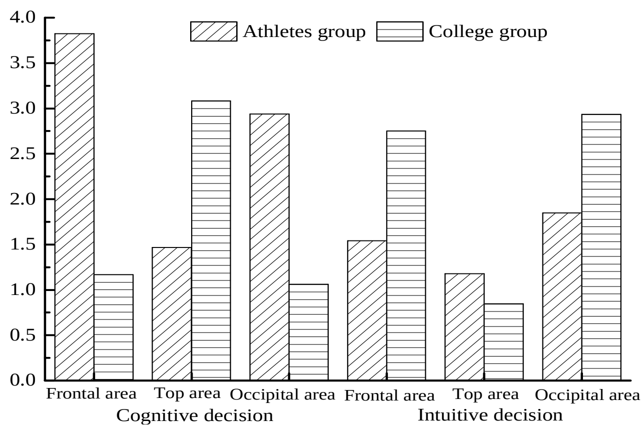

Figure 8. Comparison of P2 peak amplitudes of different groups under two decision-making tasks

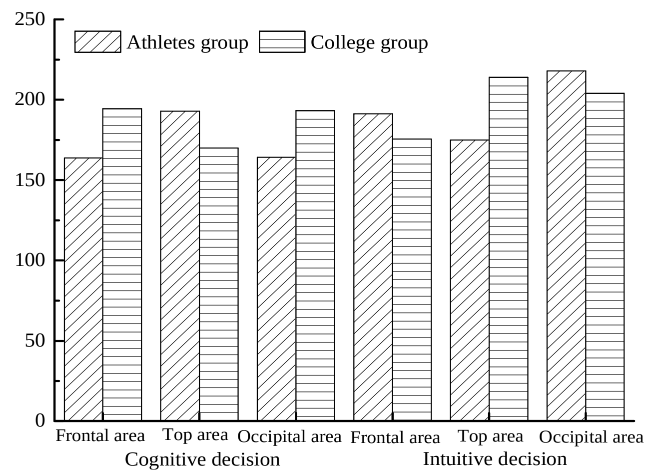

Figure 9. Comparison of P2 latency periods of different groups under two decision-making tasks

Analysis of the sports decision-making characteristics of high-performance tennis players

The decision making characteristics analysis of high-performance tennis players includes behaviour analysis and ERP analysis. Behaviour analysis involves accuracy, response speed and level of confidence, while ERP analysis involves P1 and P2. According to research results, the decision scores and accuracy of the player group under the two decision-making conditions were significantly higher than those of the college student group. Through cognitive and intuitive decision-making analysis, it is found that the intuitive decision-making abilities of the player group were much stronger than those of the college student group; in other words, tennis players, after specialized training, had intuitions when making decisions. There were also great differences in the confidence levels of the two subject groups. Tennis players had objective understanding of themselves while the college students were overconfident. Through ERP analysis, it can also be found that, in the information search period of the sports decision making by tennis players, stimulus conditions induced P1 and P2 waveforms, and that with the peak amplitude increasing and the latency period becoming longer, such phenomena of the player group were increasingly obvious, probably due to the spatial positioning or stimulatory interference suppression effects of their brains.

Conclusions

This paper adopts the ERP method and uses pictures of tennis teaching match as stimulus materials to study the sports decision-making behaviours and cognitive mechanisms of tennis players and ordinary college students. The specific conclusions are as follows:

(1) Under the two decision-making tasks, the response time of the college students (about 900ms) was significantly longer than that of the player group (about 700ms).

(2) Under the two decision-making tasks, the P1 peak amplitudes of the player group was significantly smaller than those of the college student group; for P2, in terms of cognitive decision, the peak amplitude of the player group was higher than that of the college student group while in terms of intuitive decisions, the peak amplitude of the college student group was higher.

(3) The intuitive decision-making abilities of the player group are far stronger than those of the college student group; in other words, tennis players have intuitions when making decisions after specialized training.

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