EEG analysis of Attention Resource Allocation of Tennis Players

Yan Liu[1*], Xin Sun[2]

ABSTRACT

In this paper, event-related potential (ERP) technology is used to study the distribution of attention resources of tennis related information by tennis experts, and to preliminarily explore the reasons for the perception advantages of sports experts. The study included two separate experiments. In the first experiment, the point-probing paradigm was used to study the response time of attention bias characteristics under different emotions. In the second experiment, ERP technology was used to study the attention resources allocation method of tennis experts to the tennis scene, trying to explain the expert's attention advantage from the perspective of central nervous system. Through this study, we find that for the tennis experts, there is an attention competition between the tennis scenes and the negative emotional faces, which shows that in the presence of attention competition, tennis experts will have a higher attention level to the scene information related to professional skills; sports experts have an attention bias tendency to skill-related scene information, which may be the mechanism behind the phenomenon that "experts can process scene information faster or at a higher level".

Key Words: Expert-Beginner, Attention Resource Allocation, Attention Bias, ERP, LPP

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Introduction

In the sports field, competition is a pleasure, and at the same time a psychological challenge. High-level sports competitions have extremely high requirements to the athlete's physical and mental abilities (Nikendei *et al*., 2016).

In various types of racket-holding and net-separating sports (such as tennis, badminton, table tennis), when facing sports scenes with obvious time limits and uncertain stimulations and reactions, outstanding athletes can behave calmly and unhurriedly, with a feeling of "take your time"; while average athletes were flustered, catching one ball and losing the other, feeling no time to make effective responses (Ronconi *et al.*, 2016). In sports, when facing the same perception environment, excellent athletes can make earlier and more accurate judgments on perception objects than ordinary athletes, it's mainly due to the key role of the perception subjects, namely the athletes' psychological factors in the performance (Xu *et al.*, 2016).

The differences in sports performance and perception skills between expert and beginner athletes have led to extensive research in the sports field. As early as in 1991, Abenrethy *et al*., used a response time study to compare the differences in visual search and perceptual decision-making between expert and beginner athletes in order to explore the behavioral performance of expert athletes in visual strategies. Subsequently, Tenenbaum *et al*. also used the expert-beginner research paradigm to study the perceptual predictive characteristics of expert tennis player, average tennis player and beginner tennis player, so as to explore the decision-making advantages of expert athletes (Ding *et al*., 2016). Attention ability not only

Corresponding author: Yan Liu
Address: [1]College of Sports Science, Harbin Normal University, Harbin, 150000, China; [2]Harbin Finance University, Harbin, 150000, China
e-mail ✉ yanliu30912@aliyun.com
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affects the athletes' learning and training of sports skills during everyday training, but also restricts the athletes' normal performance on the sports field. It is an important psychological guarantee for athletes to achieve excellent results. For the excellent athletes, both their below-bar performances on the court and errors in daily training have closely related to their attention status, which played a decisive role in this. The study found that sports experts have significant advantages in visual searching strategies, attention maintaining ability, and selective attention (Guo *et al.*, 2016). But what are the reasons for this advantage? Compared to beginner athletes, why do expert athletes have so many advantages in perceptual skills, especially in selective attention? These issues have yet to be further studied. From this we can see that researches on the attention have important significance in the field of sports expertise (Spapã *et al.*, 2017). Many past studies have focused on the differences between experts and beginners, while there has been no adequate discussion of the underlying causes of these differences, which is short of theoretical depth. Most earlier studies used behavioral correctness and response time to conduct research, which cannot well explain the psychological process of expert athletes. In recent years, with the application of electrophysiology and brain imaging technology, more and more researches are beginning to use these techniques to explore the differences in brain regions and central nervous system between experts and beginners (Hyde *et al.*, 2016). However, in the applied paradigm, more often than not, experiments are conducted using actual videos with higher ecological validity, which is difficult to achieve the accuracy required by electrophysiology such as ERP technology (Bell *et al.*, 2016). In future researches, besides more discussion on the reasons of the differences between experts and beginners, more scientific and rational theoretical mechanisms, as well as differences in the central nervous system are also subjects worth of in-depth discussion and researches (Silvoni *et al.*, 2015).

Methods

Experiment 1: Characteristics of attention bias of tennis experts under different emotions

15 professional tennis players were selected as tennis players (level 2 or above sports level is required), and 15 ordinary college students are selected as normal college students. The average professional training period of tennis players is 6 years, and the normal college students do not have professional training experiences, the average age of the two groups was 23 years old (Tang *et al.*, 2017). All subjects tested were right-handed, with normal uncorrected visual acuity (UCVA) or corrected visual acuity (CVA).

This experiment uses a mixed design of 2 (tennis player, normal college student) ×3 (image launching type: positive, neutral, negative) ×3 (word type: positive, neutral, negative), in which the group is a between-subject variable, emotional titer is an internal-subject variable (as shown in table 1).

Table 1. Arousal and Pleasantness of pictures in each emotional dimension

	Positive pictures	Negative pictures	Neutral pictures
Pleasantness	3.65±.092	1.64±0.84	2.85±0.82
Arousal	2.91±1.01	3.01±1.10	2.92±1.04

The experimental procedure is divided into two phases: practice phase and formal test phase.

Practice phase: the main purpose of the practice is to prevent the participants' unfamiliar of the stimulus presentation and keyboard operations from affecting their response time in the formal tests. Before the formal test, each participant conducted the practice experiments for 12 times, the practice trails are the same as the formal tests, after confirming the participants are familiar with the entire experiment procedure, they entered the formal experiments. In this stage, the data of collected response time and reaction accurate rate would not be used as the final analysis data.

Formal test phase: participants are required to watch words in pairs presented on the screen and press the corresponding letter key to react. E-prime records the response time and reaction accuracy rate. The recorded data is the final statistical analysis data. There are 350 trails and the time is about 20 minutes.

Experiment 2: tennis expert's attention bias to the tennis scene

19 professional tennis players were selected as tennis players and 19 amateurs were selected as beginner tennis players. Expert tennis players must be level II and above national athletes with more than 6 years professional training experiences, their frequency of playing tennis must be more than 3 times per week for more than 2 hours each time and for a period of more

than 2 years. All subjects tested were right-handed, with normal UCVA or CVA.

The experiment lasted for 90 minutes, 36 data entered the final analysis, with 18 people (8 females) in each group. In the experiment, 1 beginner did not correctly follow the instructions to conduct the experiment, 1 tennis expert has the same professional level in basketball, so their data was removed. Independent sample t-test showed that the tennis player's exercise time, competition time, and number of games were significantly higher than the beginner group (see Table 2).

Table 2. Independent sample t-test of experts and beginners in participation time length, playing times and playing frequency (average value SD)

	Participation time, length/month	Playing times, times/month	Playing frequency, hours/time
Expert	86.67±23.48	2.5±0.51	18±3.14
Beginner	2.33±2.2	1.42±0.91	2.17±2.12
t	15.166**	4.391**	17.713**

*$p<0.05$

This study used a mixed experimental design of 2 (scene types: tennis and non-tennis)×2(stimulus types: mixed pictures and single pictures)×2 (groups: experts and beginners), in which different scene types (tennis, non-tennis) and different types of stimuli (mixed pictures, single pictures) are intragroup variables, and experts and beginners are between-group variables. The dependent variable is response time, the magnitude of LPP.

Results and discussion

Experiment 1

Take group as the between-subject variable to conduct 2(group)×3(image valence) repetitive measurement variance analysis to the response time under the launching of the three kinds of images. The main effect of emotion valence is significant, under the launching of negative pictures, the edge of valence main effect is significant, the response to the negative words is the fastest. The main effect of groups is not significant.

The results showed that experts and beginners did not show attention bias towards the negative emotions. There are two possible reasons for this:

(1) The experiment materials selected common negative emotion pictures, which could not well reflect the regulation effects of the sports experts on negative emotions. This suggests that whether sports experts have attention bias towards specific information, namely its expertise-related information.

(2) The study on response time was not sensitive enough to reflect the psychological process of the reaction experts. This suggests that the studies should use more sophisticated instruments to conduct the researches and explore the psychological processes of the sports experts.

Experiment 2

Take group as the between-subject variable to conduct 2(group) ×3 (scene type) repetitive measurement variance analyses. The results showed that, the main effect of the group response time was not significant, indicating that there was no significant difference in the response time between the tennis expert group and the tennis beginner group. The main effect of the group was also not significant, indicating that there was also no significant difference in response time between the expert group and the beginner group. The interaction effect is not significant.

(1) Mixed picture-induced LPP amplitude

Simple effect analysis showed that the expert group presented a sharp edge on the amplitude of LPP induced by the overlaid pictures of different scene types (as shown in figure 1).

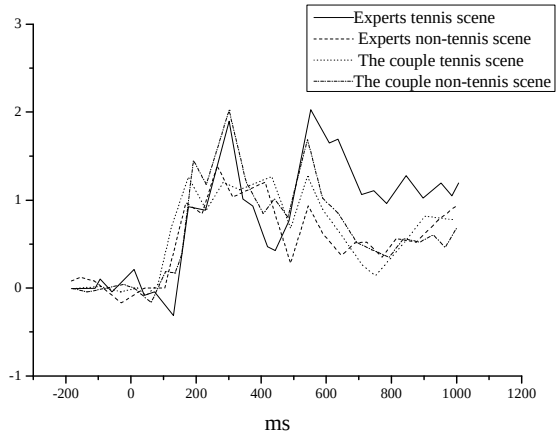

Figure 1. Differences in LPP amplitudes of mixed images

The LPP amplitude induced by the overlaid pictures of the tennis scene and negative emotional faces of the expert group was significantly greater than that of the pictures of non-tennis scene and negative emotional faces. There was no significant difference in the amplitude of LPP induced by overlaid pictures of different scene types in the beginner group. The

amplitude of LPP induced by overlaid images of tennis scenes and negative emotional faces showed significant edge differences in different groups.

(2) Single scene picture-induced LPP amplitude
Simple effect analysis showed that, the expert group showed extremely significant differences in the LPP amplitudes induced by different types of single scene pictures, indicating that the expert group's LPP amplitude induced by the tennis scene was significantly greater than the LPP amplitude induced by the non-tennis scene pictures. In comparison, the beginner group did not show significant differences in LPP amplitude induced by different types of single scene pictures. In the LPP amplitude induced by a single picture of the tennis scene, there was a significant difference between the expert group and the beginner group, indicating that the LPP amplitude of the tennis scene of the expert group was significantly greater than the LPP amplitude of the tennis scene of the beginner group (as shown in figure 2).

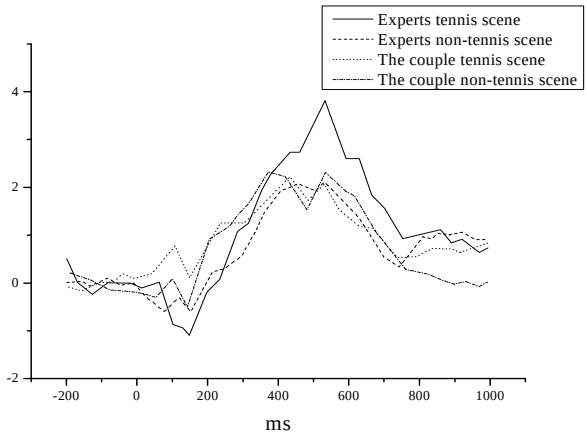

Figure 2. Differences in LPP amplitudes induced by single tennis picture

(3) Single negative emotional face picture-induced LPP amplitude
Take group as the between-group variable to conduct 2(group)×2(scene type launching) repetitive measurement variance analysis to a single negative emotional face picture. The launching effect of the scene types was not significant, indicating that there was no significant difference in LPP amplitude induced by negative emotional faces under the launching of tennis scene. The main effect of groups was not significant, indicating that experts and beginners had no significant difference in LPP amplitude induced by negative emotional faces. The interaction effect is also not significant (as shown in figure 3).

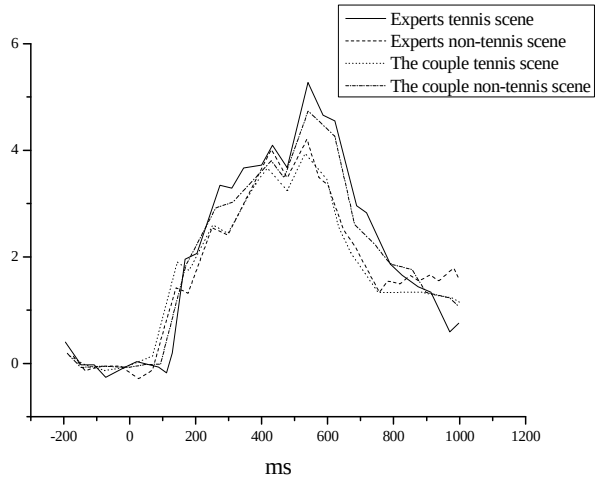

Figure 3. Differences in LPP amplitude induced by negative emotional faces

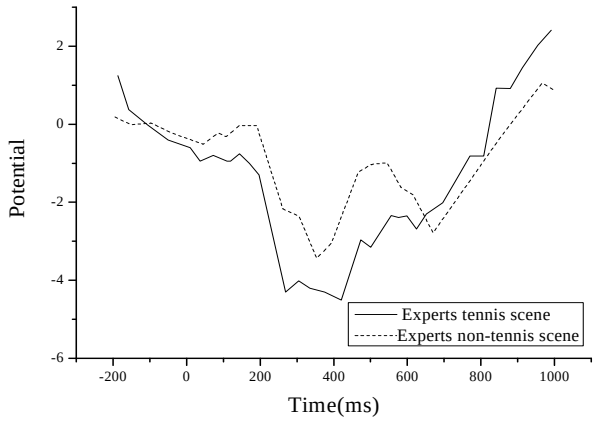

Figure 4. Attention competition of tennis experts

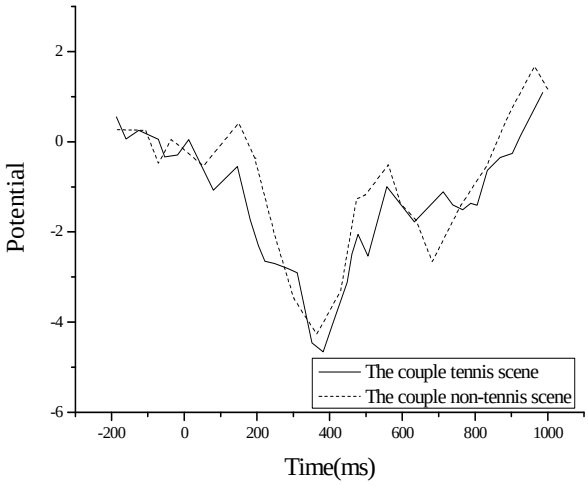

Figure 5. Attention competition of tennis beginners

(4) LPP amplitude of attention competition
Simple effect analysis showed that the expert group shows extremely significant differences in the attention competition amplitude induced by the mixed pictures of different sports scene types, indicating that the LPP amplitude induced by tennis scene of the expert group is significantly greater than that of the mixed pictures of non-tennis scene. In comparison, the beginner group did not show a significant difference in the LPP amplitude induced by different types of mixed images (as shown in figure 4 and 5).

Conclusion and Prospects

The purpose of this study is to investigate whether tennis experts have attention bias to the tennis scenes, so as to reveal the intrinsic mechanisms of the sports experts in various cognitive skills, especially the advantages of selective attention. The results show that, first, for tennis experts, the amplitude of LPP induced by tennis scene is significantly greater than that of non-tennis scene, but there is no significant difference in the beginner group. Second: Negative emotional faces triggered a significant negative attention bias, and the superimposed mixed pictures of tennis scenes and negative emotional faces induced a significant attention competition in the tennis expert group, indicating that when skill-related scene information and negative emotional faces are presented in one view at the same time and they are competing for attention resources, the tennis expert will have a higher level of attention to the scene information.

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