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An ERP Study on the Specificity of Taekwondo Athletes to Threatening Information Processing

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Abstract:

In the current study, event-related potential (ERP) technology is used to investigate the P1 and N1 components in the early processing stage and P3 component in the late processing stage of taekwondo athletes with threatening pictures in real competition situations as stimulus materials. The results present two findings: 1) In the early processing stage, compared with general threats, special threats induced a larger P1 amplitude and a longer N1 latency, and show significant expert advantages in P1 components; and 2) In the late processing stage, the special threat induced a larger P3 amplitude than the general threat, and the P3 amplitude induced by the expert group was significantly larger than that of the novice group under the special threat condition, indicating that taekwondo athletes had class specificity in the processing of threatening information, that is, specific threats had processing advantages over general threats, and there were early and late differences in the processing of specific threatening information.

Keywords: *Taekwondo athletes, Visual search, Threatening information, Event related potential*

I. INTRODUCTION

Negative information, especially threatening information, in the effective processing environment is crucial for the survival and development of individuals[1,2]. Threatening information, compared with other information, is characterized by automation and priority, and is easier to activate the attentional processing system of the brain and automatically activate certain brain regions responsible for defense, such as the amygdala and the gray matter around the aqueduct, thus enabling individuals to quickly develop behavioral tendencies to avoid or fight back[3,4]. Previous studies on the use of negative emotional images such as anger and fear as the main carriers to convey threatening information have found that athletes in fighting events have advantages in processing threatening information, and have detected higher levels of activation in the corresponding brain regions. Behavioral research reveals that expert athletes are more alert to threatening information, showing faster response speed and higher response accuracy[5]. Eye-tracking methodology has shown that the visual search model of expert athletes is very cost-effective and has more and more reasonable visual search strategies, and their gaze points are mostly concentrated in key areas[6,7]. Electrophysiological studies have found that expert athletes are more sensitive to threatening information and have shown certain advantageous effects in the early stage of automatic processing.

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Compared with neutral information, threatening information induces a larger P1 amplitude and a longer N1 latency[8,9]. Studies have further confirmed that in the late processing stage, threatening information also induces larger amplitude of P3 and LPP than neutral information[10,11].

Threatening information often has the dual nature of "emotion-meaning", i.e., threatening information often carries emotional information. For example, the emotional material of fear or anger used in previous studies not only conveys a piece of threatening information but also a piece of emotional information[12]. The difference lies in that fear implies the existence of potential threats in the environment, while anger symbolizes a more direct threat. As the emotional processing also has the priority feature, which will inevitably interfere with the processing of threatening information[13], so far it is still unclear whether the fighters who do not carry the emotional information but have the threatening information have the specificity of processing. In view of this, at present, with the help of event-related potential technology, the electrophysiological indexes of threatening information processing of Taekwondo athletes were investigated with pictures in real game situations without emotional information but threatening at the same time as stimulation materials, so as to test whether Taekwondo athletes have specificity in processing threatening information and further determine whether this processing specificity is category specificity. The expectation hypothesis was that taekwondo athletes' processing of threatening information was category-specific, and reflected in the P1 and N1 components in the early processing stage and the P3 component in the late processing stage. Moreover, there were differences between the early and late processing of specific threatening information.

II. METHODOLOGY

2.1 Subjects

A total of 20 taekwondo athletes (expert groups) and 20 taekwondo beginners (novices) were selected, among which, the expert groups (9 males and 11 females) with the average age of 20.95 ±2.01 years old and the average training period of 6.75 ±1. 74 years old were all athletes at the national level II and above; the novices (10 males and 10 females) with the average age of 19.35± 0.75 years were all ordinary college students in taekwondo elective classes, with no exercise level (see Table I).All subjects had visual acuity (or after correction) of 5.0 or above, were right-handed, and had no history of neurological disorders.

Table I. Basic information of subjects

Groups	Gender		Age/years old	Training years /y	Level			Total/person
	Male	Female			Top-notch player	Level I	Level II	
Expert group	9	11	20.95 ±2.01	6.75 ±1.74	2	7	11	20
Novice group	10	10	19.35± 0.75	0	0	0	0	20

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2.2 Experimental Materials and Evaluation

The general threatening materials used in the experiment were from IAPS[14], and the special threatening materials were 48 pictures of real situations in which the red side effectively hit the opponent's score point with fist or leg in Taekwondo competition, and the score was 1 point or above. In addition, 30 students of taekwondo elective class were asked to rate the threat degree of the selected pictures with a 9-point scale. Finally, general threatening pictures and special threatening pictures (24 each) with the threat degree of more than 7 points were selected as the stimulus materials for the experiment. The independent-samples t-test (t = 1.97, p > 0.05) was performed on the general threat images (7.28 ± 0.22) and special threat images (7.38 ± 0.19), and no statistically significant difference was found. All materials were post-processed with unified standard using Photoshop CS6 software.

2.3 Experimental Procedures

The experiment was carried out in a laboratory with appropriate temperature and silencing. After completing the preparatory work before the experiment, the subjects sat in an office chair about 70cm away from the computer screen. Before the start of the experiment, the computer screen would first present the subject with a gaze point "+"for 500ms, and then a threatening picture (special threat/general threat) for 1,000ms. The subject should determine the type of threat the picture represented as quickly as possible, and then press the "J" key quickly if the general threat was presented, and then press the "F" key quickly if the specific threat was presented. When the presentation time exceeded 1,000ms or the subject made a key reaction, the system would automatically enter the next program. In order to balance the relationship between speed and accuracy and enable the subjects to concentrate most of their attention on the identification of threat categories, the response window technology was used to force the subjects to respond within the specified time, and the feedback window was presented for 1,500ms.According to the category experiment of threats, a total of 288 trials were designed, with 144 trials for special threats and 144 trials for general threats, which were randomly presented. The experiment flow is shown in Fig 1.

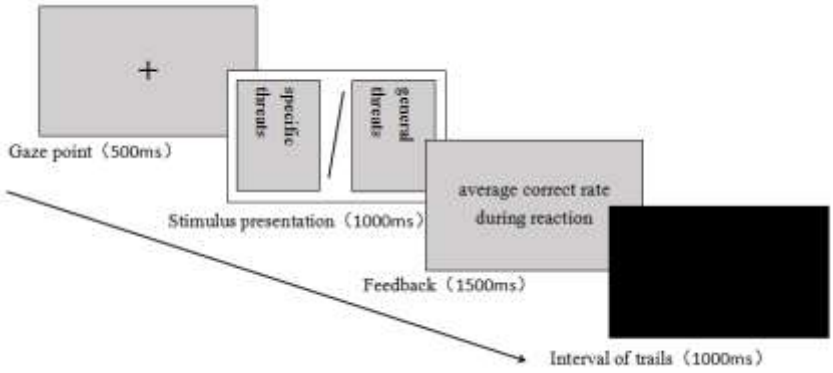

Fig 1: Schematic diagram of experimental flow

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2.4 ERPs Data Recording and Analysis

In the experiment, E-Prime 2.0 software was used to present the corresponding threat stimuli, and Brain Products electroencephalogram recording and analysis system was used to collect and analyze electroencephalogram data. EEG of each electrode position (arranged according to international standards) was recorded using a 64-lead Ag/AgCI electrode cap, and the reference electrode was FCz. Electrodes were placed at 1.5cm lateral and below the right eye, respectively, to record horizontal electrooculogram (HEOG) and vertical electrooculogram (VEOG).According to previous and current research purposes[15,16], P3/4, O1/2, and PO3/4 electrode points were selected for analysis of P1 component (70–130ms), P5/6, P7/8, and PO7/8 electrode points were selected for analysis of N1 component (140–180ms), and CP1/2, P1/2, PO3/4, Pz, CPz, and POz electrode points were selected for analysis of P3 component (300–500ms).In the statistical analysis of P1, N1 (peak amplitude and latency) and P3 (average amplitude), the three-factor repeated measurement analysis of variance (ANOVA) of 2 (group: experts and novices) ×2 (threat category: specific threat and general threat) ×3 (hemisphere: right, middle and left) was used.

III. RESULTS

3.1 Behavioral Outcome

The analysis of variance of repeated measurement of reaction time showed that the difference of principal effect between groups was not significant [$F(1,38) = 0.22$, $p = 0.415$, $\eta^2 = 0.18$], the difference of principal effect of threat category was significant [$F(1,38) = 4.83$, $p = 0.034$, $\eta^2 = 0.11$], the reaction time under general threat condition ($M = 427.39$, $SD = 9.14$) was significantly longer than that under specific threat condition ($M = 397.61$, $SD = 9.07$).The repeated measurement variance analysis of the response accuracy showed that there was neither significant difference in the main effects between groups [$F(1,38) = 0.71$, $p = 0.259$, $\eta^2 = 0.03$], nor significant difference in the main effects of threat categories [$F(1,38) = 0.31$, $p = 0.581$, $\eta^2 = 0.01$]. The average response accuracy under various conditions was above 96%.

3.2 ERP Result

3.2.1 P1 component

No significant principal effect and interaction effect were found in the three-factor repeated measurement analysis of variance (ANOVA) of P1 latency of 2 (group: expert, novice) ×2 (threat category: general threat, special threat) ×2 (hemisphere: left hemisphere, right hemisphere) ($P > 0.05$).The results of three-factor repeated measurement variance analysis on P1 wave amplitude showed that the main effect between groups was significant [F (1, 40) = 7.02, $p = 0.011$, $\eta^2 = 0.149$]. The expert group ($M = 6.14$, $SD = 0.56$) showed a larger P1 wave amplitude than the novice group ($M = 4.00$, $SD = 0.58$).In addition, the interaction between groups and threat categories was significant [F (1, 40) = 4.93, $p = 0.032$, $\eta^2 = 0.110$].Simple effect analysis showed that under general threat conditions, the expert group ($M = 5.82$, SD

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= 0.57) produced a greater P1 amplitude than the novice group (*M* = 4.09, *SD* = 0.59).Similarly, under specific threat conditions, the expert group (*M* = 6.45, *SD* = 0.57) also produced a larger P1 amplitude than the novice group (*M* = 3.92, *SD* = 0.60).The interaction between threat category and hemisphere was significant [*F* (1, 40) = 12.29, *p* = 0.001, η^2 = 0.235].Simple effect analysis showed that specific threats (*M* = 5.35, *SD* = 0.41) induced greater P1 amplitude in the left hemisphere than general threats (*M* = 4.89, *SD* = 0.37). The total average amplitude of P1 under various conditions is shown in Fig 2.

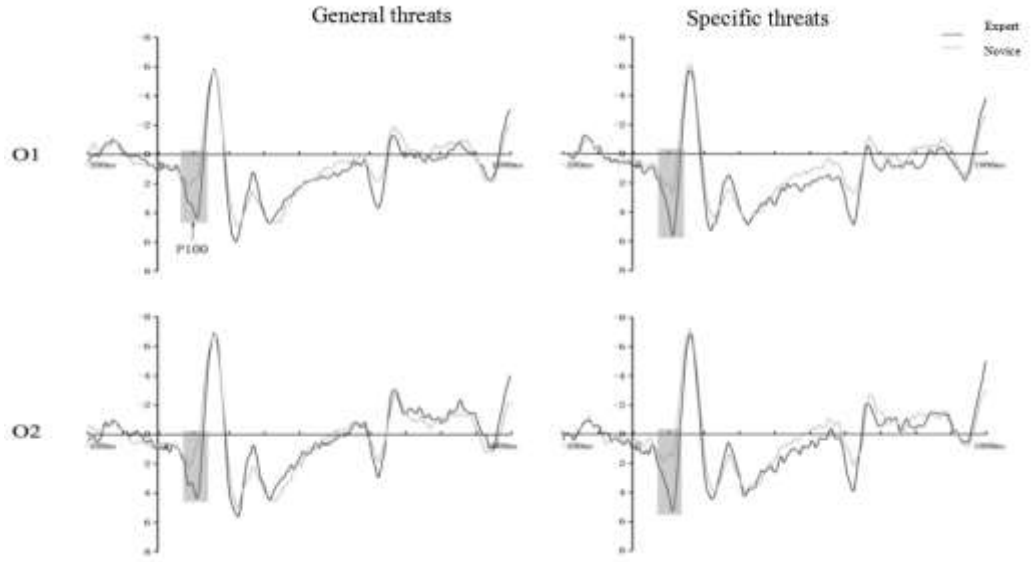

Fig 2: Total average amplitude of P1 under various conditions

3.2.2 N1 component

The results of three-factor repeated measurement analysis of variance (ANOVA) of N1 latency of 2 (group: expert, novice) ×2 (threat category: general threat, special threat) ×2 (hemisphere: left hemisphere, right hemisphere) showed that the main effect of threat category was significant [*F* (1, 40) = 11.57, *p* = 0.002, η^2 = 0.224]. Special threats (*M* = 157.67, *SD* = 1.42) induced longer N1 latency than general threats (*M* = 155.62, *SD* = 1.47).Three-factor repeated measurement analysis of ANOVA showed that the main effect of N1 amplitude was significant in the hemisphere [*F* (1, 40) = 17.86, *p*< 0.001, η^2 = 0.309], and that in the left hemisphere (*M* = 6.84, *SD* = 1.15) was higher than that in the right hemisphere (*M* = -8.73, *SD* = 1.15).In addition, no significant main effect and interaction effect were found in the amplitude of N (*P*> 0.05).

3.2.3 P3 component

The results of three-factor repeated measurement analysis of variance (ANOVA) of P3 average amplitude of 2 (group: expert, novice) ×2 (threat category: general threat, special threat) ×3 (hemisphere:

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left, middle and right hemisphere) showed that the main effect in the hemisphere was significant [F (2, 80) = 3.30, p = 0.042, η^2 = 0.076], and the left hemisphere (M = 6.40, SD = 0.40) exhibited greater P3 amplitude than the right hemisphere (M = 5.94, SD = 0.46).The interaction between threat category and hemisphere was significant [F (2, 80) = 12.07, p< 0.001, η^2 = 0.232].Subsequent simple effect analysis showed that specific threats (M = 6.61, SD = 0.42) induced greater P3 amplitude in the left hemisphere than general threats (M = 6.19, SD = 0.40).In addition, the results also found that the interaction effects among groups, threat categories and hemispheres were significant [F (2, 80) = 3.34, p = 0.040, η^2 = 0.077].The simple effect analysis showed that under the specific threat condition, the expert group (left hemisphere: M = 7.52, SD = 0.58; middle hemisphere: M = 7.00, SD = 0.60; right hemisphere: M = 6.98, SD = 0.65) exhibited larger P3 amplitude in the left, middle and right hemispheres than the novice group (left hemisphere: M = 5.69, SD = 0.61; middle hemisphere: M = 5.09, SD = 0.63; right hemisphere: M = 4.91, SD = 0.68), but this effect was not observed under the general threat condition. The total average amplitude of P3 under various conditions is shown in Fig 3.

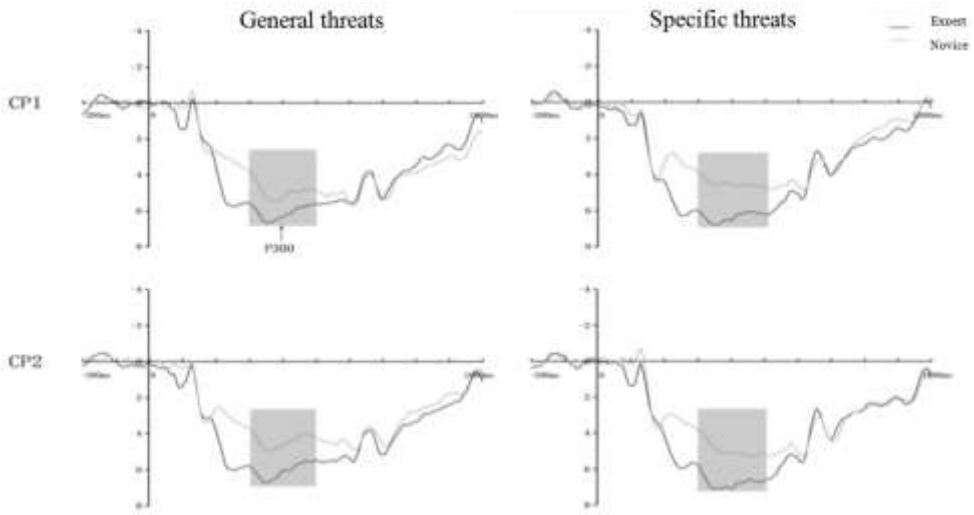

Fig 3: Total average amplitude of P3 under various conditions

IV. DISCUSSIONS

In this study, the electrophysiological characteristics of taekwondo expertise affecting threatening information processing were examined using behavioral and ERP techniques. The behavioral results showed that taekwondo athletes had shorter response time to specific threats and had more significant response advantages compared with general threats. The study believes that long-term professional training and competitions keep taekwondo athletes in special threat situations and form dominant responses to special threat stimuli, showing higher alertness and sensitivity to special threat information, thus significantly promoting the processing of special threat information.

The ERP component of a specific time course represents the cognitive processing characteristics of the

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human brain for specific types of information. Some studies have pointed out that the processing of specific categories of information must have its own unique cognitive neural mechanism, namely "category specificity"[17].The ERP results in this study showed that different types of threatening information did trigger different cognitive processing, which was reflected in both early and late processing stages. In the early processing stage, the special threat induced a larger P1 amplitude and a longer N1 latency than the general threat, and showed a significant expert advantage in P1 component, indicating that the special threat information had its unique characteristics of automation and priority processing in the early processing stage. The P1 and N1 components are important indicators for the investigation of visual processing[18,19], and the investigation results based on P1 and N1 components in the early processing stage were consistent with the relevant research results in the past[20].It has been suggested that the processing advantage of athletes for specific information in the early stage of visual processing may be the result of their long-term adherence to professional training, because long-term professional training enables athletes to accumulate rich technical and tactical experience in the brain, i.e., cognitive template, which enables the early processing stage to quickly match and process the captured antecedent information with the existing cognitive template, showing a directional acceleration of specific categories of information[21,22].Some studies also believe that athletes can timely find the key information of specific categories of stimulation and quickly identify and process it, with faster coding, thus showing the specificity of early processing of specific categories of information[23,24]. Some studies have also pointed out that the reaction preference for specific categories of information and domain specificity are the main reasons for the specificity of specific categories of information processing in the early processing stage[16].

In the late processing stage, the special threat induced a larger P3 amplitude than the general threat, and under the condition of special threat stimuli, the expert group induced a larger P3 amplitude than the novice group and showed significant processing advantages, indicating that taekwondo athletes also reflected the specificity of special threat information processing in the late processing stage. In previous studies, the negative emotional information with fear or anger was generally regarded as threatening information directly. In fact, this kind of information not only transmits the threatening information, but also transmits the emotional information, and the emotional information is not equal to the threatening information. When using this kind of material to investigate the influence of the threatening information on cognitive processing, the brain will inevitably be interfered by the emotional information. In the current study, threatening pictures without emotional information in real competition situations are used as stimuli materials, so taekwondo athletes can process the specific threatening information more deeply in the late processing stage because they are not interfered by the emotional information. In addition, based on the results of the current research, it is believed that there are differences between the early and late stages in the processing of special threat information for taekwondo athletes. That is to say, the early stage is the stage of automatic detection and processing of relatively prominent special threat information. In other words, the processing of special threat information for taekwondo athletes in this stage is an automatic and unconscious processing process, and an instinctive response after long-term professional training. The late stage is for controlling and processing special threatening information, that is to say, under the condition of sufficient cognitive resources, special threatening information will be selectively processed in depth.

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V. CONCLUSIONS

Taekwondo athletes have category specificity in the processing of threatening information, i.e., special threats have more processing advantages than general threats. Moreover, there are differences between early and late stages in the processing of special threatening information that the early stage is for measurement and processing, displaying an automatic processing feature, while the late stage is for controlling and processing stage, displaying a selective deep processing feature.

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