Influence of Attentional Resource Allocation in the Brain on Exercise Performance

Sotoyuki USUI, Yoshiaki NISHIHIRA and Masaki FUMOTO

Department of Human Development and Sport Science, School of Human and Social Science, Tokyo International University, 2509 Matoba, Kawagoe, Saitama, 350-1198 Japan
Graduate School of Comprehensive Human Science, University of Tsukuba 1-1-1 Tennoudai, Tsukuba, 305-8574, Ibaraki Japan

Abstract

USUI, S., NISHIHIRA, Y. and FUMOTO, M. Influence of Attentional Resource Allocation in the Brain on Exercise Performance. Adv. Exerc. Sports Physiol., Vol.19, No.4 pp.139-142, 2013. This study focused on sensory information in the brain, particularly a quantitative aspect of attention, attention-processing resources. The influence of the level of attention-processing resource allocation on exercise performance in humans was investigated using the dual task method, P300 potential representing brain reactions, and reaction time. Tracking errors increased and the accuracy decreased as the number of tracking tasks increased. The reaction time delayed as the tracking speed increased. The P300 latency and reaction time delayed as the tracking speed increased. These results suggest the P300 amplitude is independent of the processing resource level in the brain by manipulating the tracking speed, i.e., manipulation of the tracking speed may influence processing in the brain involved in the P300 latency and reaction time.

1. Introduction

To learn exercise, repeated training is necessary, during which diverse sensory information, such as somatic sensory information from the skin, muscles, tendons, and joints and visual, auditory, and vestibular sensations, is efficiently processed in the brain, in addition to perception, judgment, and exercise performance to acquire the target exercise pattern. Particularly, in team competitions, such as ball games, information-processing in the brain within a short time may have a decisive influence on later performance in many cases. For example, when a ball is received, it is necessary to judge the surrounding condition, efficiently decide on the next move, and process it within a short time, for which the speed of early sensory processing in the brain, i.e., how information is efficiently processed, is very important to increase the exercise performance.

It was confirmed in previous studies that short-term (several ten-msec) sensory information transmitted to the brain has a marked influence on the reaction time (6). It has also been confirmed that some sensory information to which the person is paying no attention may markedly influence exercise performance on analysis using mismatch negativity, which is attention-related potential evoked in the brain (3). The processing of sensory information in the brain while actively paying attention has also been investigated, and the N250 potential, evoked only when attention is paid to the target stimulation, was discovered and confirmed to have a marked influence on exercise performance (5). Therefore, it was clarified that diverse sensory information is consciously or unconsciously processed in the human brain and it subsequently influences exercise performance. However, the quantitative aspect of the processing of diverse sensory information in the brain has not yet been clarified in Japan or other countries. It is assumed that the sensory information-processing capacity of the human brain is limited. For example, the performance level may decrease when several tasks are simultaneously performed, compared to that on performing a single task. Although attention-processing resources are allocated to each task, since the resources are limited, tasks to which processing resources are sufficiently allocated may be performed well but tasks with insufficient allocation may be performed poorly. In this study, we focused on sensory information in the brain, particularly a quantitative aspect, attention-processing resources. The objective was to clarify the influence of the level of attention-processing resource allocation on exercise performance in humans using the dual-task method, P300 potential considered to represent brain reactions, and the reaction time.

2. Methods

Subjects

The subjects were 15 healthy right-handed adults. Each subject sat on an armchair for the experiment in a
comfortable position in an electricity-shielded room. No subject had a past medical history of neurological or psychiatric disease. Consent to participate in the experiment was obtained after explanation of the content.

Oddball task for somatic sensations

To evoke P300 and attention-related potentials out of event-related potentials, electric stimulation with 0.2-msec rectangular waves was randomly applied to the right thumb and middle finger at random stimulation intervals of 800-1,200 msec. The target and standard stimulations were loaded at a stimulation probability of 2:8. The combination of the target and standard stimulations was randomly set among the subjects. The subjects were instructed to react to the target stimulation by pushing a button with the right index finger when it was perceived.

Target line-tracking task (performed under dual-task condition)

Two lines were arranged on an oscilloscope placed 1 m in front of the subject: one was the target (target line) and the other indicated the force produced by handgrip movement by the subject (force line). The height and width of the lines were about 1 mm and 9 cm, respectively. The subject tracked the vertically moving target line with the force line. The upper and lower limits of the force were set at 50 and 0 N, respectively. Before starting the tracking task, the target line stopped at the position of 25 N. Upon the experimenter’s cue, the subject immediately set the force line at the target line. The target line started to move upward after 3 seconds and the subject immediately tracked it with the force line. Under the dual task condition, somatic sensory stimulation was loaded 5 seconds after the target line started to move, and the subject simultaneously performed both the oddball task for somatic sensation and the tracking task. One session was comprised of 3 blocks, and about 90 rotary stimulations were loaded per block.

Recording and analysis

Brain waves were derived from 5 sites of the scalp (Fz, Cz, Pz, C3, and C4), setting linked earlobe references (0.5-100 Hz). The inter-electrode resistance was set at 5 kΩ or less at all sites. Electro-oculograms were simultaneously recorded to monitor ocular movement and blinking. The analytical time was set at 750 msec, including 100 msec before stimulation. Regarding RT, the rise of the mechanogram evoked by pushing the button during the 100-650-msec period after target stimulation was regarded as the latency. Trials containing excess ocular movement, blinking, and reaction errors were excluded from the addition. Data were sampled at 500 Hz. A negative potential appearing 100-180 msec after stimulation was regarded as N140, and a positive potential appearing 250-500 msec after stimulation was regarded as P300. To investigate the accuracy of the tracking task, the difference between the target and force lines at each sampling point was squared, and the square root was calculated and averaged in each block. The mean value of the 3 blocks was regarded as the error under each condition. The accuracy of tracking decreases as this value increases.

3. Results

1) Performance

In the tracking tasks, the error rates of the oddball task were 4.9 and 3.3% at high and low speeds, respectively, and those of the dual task were 14 and 13%, respectively, showing that tracking errors increased at a higher tracking speed.

2) P300 potential

Figure 1 shows the evoked event-related potentials. Under all conditions, a clear P300 potential was noted.

3) Reaction time and P300 latency

Figure 2 shows the reaction time and P300 latency. The reaction time was significantly longer in the dual than in the oddball task (P<0.05). Similarly, the P300 latency was significantly longer in the dual than in the oddball task (P<0.05).

4) P300 amplitude

Figure 3 shows the P300 amplitude. It was significantly greater in the oddball than in the dual task at both speeds (P<0.05).

4. Discussion

This study focused on sensory information in the brain, particularly a quantitative aspect of attention, attention-processing resources. The influence of the level of attention-processing resource allocation on exercise performance in humans was investigated using the dual task.

![Figure 1](image-url) The evoked event-related potentials. Under all conditions, a clear P300 potential was noted.
method, P300 potential representing brain reactions, and reaction time. Tracking errors increased and the accuracy decreased as the number of tracking tasks increased. The reaction time delayed as the tracking speed increased. These findings suggest that task difficulty could be controlled in this experiment. The P300 latency and reaction time delayed as the tracking speed increased. Since the P300 latency has been clarified to reflect the stimulation-processing time in the brain, it is assumed that the processing time varied with changes in the tracking speed, and it delays as the task becomes difficult.

The P300 amplitude decreased in the dual task rather than the oddball task. Kida et al. (4), Wickens et al. (7), and Isreal et al. (1) obtained similar findings using sensory stimulation. However, as clarified by the experimental results, the P300 potential was not influenced by the tracking speed, suggesting that it is independent of the processing resource level accompanying changes in the speed. Kida (4), Wickens et al. (7), and Isreal et al. (1) also reported that the difficulty of tracking tasks does not influence the P300 amplitude. However, Isreal et al. (2) reported that the P300 amplitude altered as the tracking task changed, suggesting that resource allocation in the brain varies depending on differences in the tracking task. As reported by Kida et al. (4), it was suggested that the P300 amplitude is independent of the processing resource level in the brain by manipulating the tracking speed, i.e., manipulation of the tracking speed may influence processing in the brain involved in the P300 latency and reaction time, but not influence the resources utilized for processing involving the P300 amplitude.

Acknowledgments
This study was carried out by the support of "Tokyo International University Grant for Special Research Projects".

References