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Technical Article

A fundamental examination of the attentional function in the rhythm game

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Abstract
This study aimed to clarify the effect of the rhythm game "Osu!" on attentional function and its factors. Participants wore an electroencephalograph and played "Osu!" for 10 minutes (four games), and the Trail Making Test was performed before and after the games. As a result of the analysis focused on the frequency of the games, only the "high frequency group" showed an effect on attentional function. From the results, it can be inferred that rhythm games can improve attentional function and can function as a training tool for game users. The results also suggest that rhythm games can be used as a health-promoting tool owing to their ability to improve attentional function.

Keywords: rhythm game; esports ; Osu! ; attentional function.

1. Introduction

In recent years, esports have become popular worldwide. According to a study by Newzoo (2020), the global esports market increased by $181.1 million between 2018 and 2019. The total number of people who watched esports videos increased by 48 million between 2018 and 2019. Moreover, esports was adopted as a demonstration sport for the first time at the 18th Asian Games held in 2018. Since then, it has been decided that esports shall be an official medal event at the Asian Games to be held in 2022. Moreover, in Japan, the Japan eSports Union (JeSU) was established in 2018 to provide an environment for the development of esports.

The Japanese Ministry of Economy, Trade, and Industry is focusing on the esports market as a new growth area in the content sector. They suggest that esports have various social implications beyond their economic effects on the surrounding markets and industries. As such, the ministry intends to promote research in the fields of medicine and education to revitalize esports. Based on the above, the esports market will continue to grow in the future. Therefore, it is consequential to conduct empirical research.

Several professional esports players state that they play rhythm games before practice or competition to improve their physical and mental skills. For example, Tylar Ninjya Blaevins, a popular professional esports player who plays the shooting game “FORTNITE,” plays the rhythm game “Osu!” as a warm-up before starting the game (Business Insider Australia, 2019). “Osu!” is a simple and straightforward, free online music game. To play the game, one uses a mouse or pen-tab to click or drag markers that appear on the screen at the right moment in time with the music or beat, and then spin the spinner on the screen. Bégel et al. (2017) conducted a review to examine the effects of rhythm games. They mentioned that training with rhythm games may lead to improved cognitive function. Hagiwara et al. (2020a) studied 10 male college students who played games for one hour a day, five days a week or more, including the game “Osu!”. They reported that attentional function was significantly improved after playing “Osu!”. However, this study was conducted on gamers in their twenties, and the effect of “Osu!” on attentional function has not been tested on participants outside of this age group. Therefore, this study aimed to study the effect of “Osu!” on the attention function and its factors to verify the effect of playing the game on attention function for the public at large. By examining the effects of rhythm games on cognitive

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functions for various generations other than game players, we can show the applicability of games and expect them to be used for purposes other than entertainment.

2. Methods

2.1. Participants

Participants included 16 healthy adult males in their 20s to 50s (mean age 39.75 ± 11.45). The contents of the experiment and the risks associated with the measurement were explained to participants, and their written and verbal consent was obtained before the experiment was conducted with full consideration of their physical condition.

2.2. Procedure

Participants were asked to complete questionnaires identifying their demographics, game frequency, experience of playing “Osu!” and mood before taking a two-dimensional mood scale. They wore an electroencephalogram (EEG) for 2 min. Subsequently, they performed the Trail Making Test (TMT) to assess the processing speed of the criterion and played “Osu!” for 10 min (four games). After finishing the game, they immediately performed TMT and filled their posttest mood on the scale of the questionnaire.

2.3. Attentional function assessment index

This study used the TMT to assess attentional function, which was divided into two parts: Part A and Part B. Part A consisted of 25 numbers, while part B consisted of 13 numbers and 12 English letters. Part A connected numbers 1 to 25 randomly placed on a paper to measure the time taken to complete the procedure. Part B connected numbers and letters randomly placed on a paper in turn and measured the time required to reach 13. The objective was to keep the pencil on the paper and connect the line as quickly as possible. If the participant made a mistake in the middle of the test, he/she must point it out immediately and correct it. In that case, the stopwatch was not stopped, and the time when the participant finished connecting the lines was recorded as the measured value.

Takaoka and Ogata (2009) suggested that TMT Part A performance reflects attentional selectivity, while Part B performance reflects convertibility and allocative performance. It requires several other functions such as recognition of numbers and letters, visual exploration, speed of joint movements of the eyes and hands, speed of information processing, flexibility of mental activity, and motor functions. In this study, we used the Japanese version of the Trail Making Test (TMT-J) Part B (Ishida & Yoshida, 2014), which is available on personal computers (PC) and tablet devices.

2.4. Evaluation of biological attentional function

This study used an electroencephalograph to measure attentional function. EEG is an electrical signal produced to process information obtained from sensory organs. Conventional EEG measurements can measure EEG signals from multiple sites, but it takes more than 30 min to wear. Moreover, because of the effect of tightening on the scalp, research using a simple electroencephalograph has become mainstream, except for precise verification research at the medical level. In this study, we used a simple electroencephalograph to measure Fp1 (left frontal lobe), as defined by the international 10-20 method.

The left frontal lobe is considered an appropriate area for obtaining the human psychological state because it has less noise due to head hair (Sakamoto et al., 2006). In this study, a band-shaped simple electroencephalograph (NeuroSky, Tokyo, Japan) that uses an EEG signal acquisition chip, and a Sports KANSEI (Littlesoftware Inc, Tokyo, Japan), an application that records acquired EEG data on a smartphone and converts it into sensitivity values, were used. The potential differences obtained from the reference electrodes on the forehead of the left frontal lobe (Fp1) and the left earlobe were amplified by the circuitry in the instrument, then numerically processed and HANNING was windowed at 512 samples/s. The EEG data were subjected to fast Fourier transform (FFT) and power spectrum analysis. The sum of the power of each frequency band was calculated from the obtained data, and the percentage of the total power was calculated subsequently. The calculation method was based on Hagiwara et al. (2020b), and the analysis was performed based on the following formula:

2.5. Analysis

To assess attentional function, the mean value of the time spent performing the TMT was calculated and analyzed using a t-test. The EEG was converted into a numerical value indicated by 0-100 for the incidence of the low-beta wave band using a Sports KANSEI. From the data, the mean value during TMT execution was calculated and analyzed using t-tests. This study was analyzed by focusing on “age” and “game frequency.” IBM SPSS Statistics (version 26.0) was used for the analysis.

3. Results

3.1. Attentional function

There was no significant difference between the mean values of the TMT execution time (sec) of the 16 participants before and after playing “Osu!.” There were no significant differences between the groups (before: M=41.13, after: M=42.83). In addition, the analysis of the low-beta band obtained from the EEG showed no significant difference. The percentage of the low-beta band decreased after playing “Osu!” (before: M=29.64, after: M=27.84).

3.2 Attentional function by age group

In the Figure 1, the horizontal axis shows the age of the participant and the vertical axis shows the difference in execution time between the first and the second TMT. The higher the value on the vertical axis, the faster the TMT execution time and the higher the percentage of the low-beta band. This result shows that there is no correlation between TMT execution time and age; however, older people may have a faster TMT execution time than young people. There was also a small correlation between EEG and age during TMT, indicating that older people showed less change in the low-beta band than younger people.

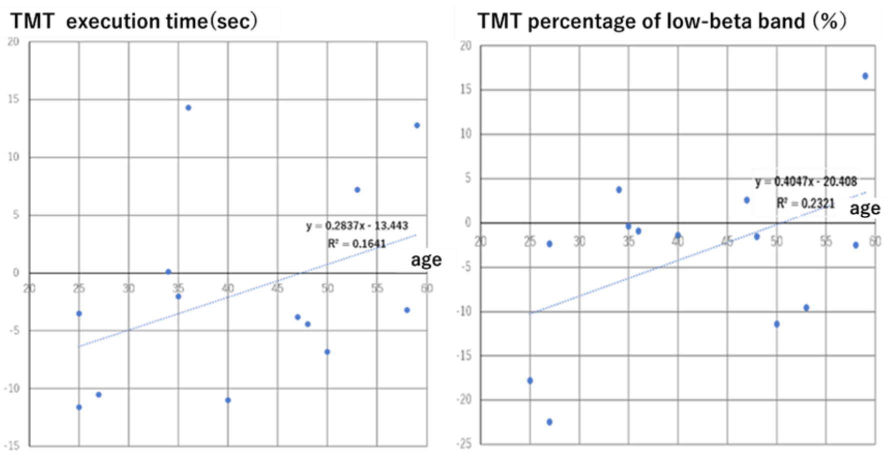

Figure 1 Differences in execution time and low-beta band between first and second TMT by age

3.3 Attentional function by game play frequency

The participants regarding game frequency were classified into three groups: "high frequency group" who play games every day, "medium frequency group" who play games occasionally, and "low frequency group" who do not play games at all. Although the number of participants varied, the high frequency group had a faster TMT execution time (before: M=33.80, after: M=31.30) than the medium frequency (before: M=41.99, after: M=46.41) and low frequency groups (before: M=44.60, after: M=51.40). In addition, the frequency of TMT execution became faster in the high frequency group. On the other hand, the TMT execution time of the medium frequency group and the low frequency group became slower.

4. Discussion

This study aimed to determine the effects and factors affecting attentional function on adult males in their 20s to 50s, and found that, on average, there was a decrease in attentional function after playing "Osu!" in terms of TMT execution time and percentage of low beta bands. Hagiwara et al.’s study (2020b), targeting people in their 20s who usually play games for more than one hour a day, five days a week or more, found that that attentional function improved after playing the game; however, the present study showed the opposite result. Since most participants of this study did not play games daily, and most of them played the rhythm game "Osu!" for the first time in this study, it is possible that unfamiliarity with the game content induced a decline in attentional function. Second, the results of the analysis focused on the age of the participants, indicating that the execution time of TMT may have been faster in the elderly than in the young. In addition, there was a weak correlation between EEG and age during TMT, suggesting that older participants may have a smaller change in the lower beta band than the younger participants. In other words, the effect of games on attentional function was greater in the elderly than in the young, suggesting that games may improve attentional function in the elderly. This is a new finding, as to the best of our knowledge, there are no studies comparing different age groups.

5. Conclusions

This study aimed to determine the effects of attentional function and its factors on adult males in their 20s to 50s while playing the rhythm game "Osu!," which is used by e-sports players as training for psychological skills. Participants included 16 adult males (mean age 39.75±11.45). TMT and EEG were used to measure attentional function before and after "Osu!," suggesting that the effects on attentional function may differ depending on the "frequency of the game."

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Institutional Review Board Statement
The study was conducted in accordance with the guidelines of the Declaration of Helsinki and approved by the National Institute of Fitness and Sports in Kanoya Ethics Committee.

Informed Consent Statement
Informed consent was obtained from all participants involved in the study.

Conflicts of Interest
The authors declare no conflict of interest.

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