

# A Study on the Effects of Elements of Games in Oddball Tasks for User’s Motivation and Event-Related Potential

TADASHI KOIKE<sup>1,†1,a)</sup> TOMOHIRO YOSHIKAWA<sup>1,†1,b)</sup> TAKESHI FURUHASHI<sup>1,†1,c)</sup>

**Abstract:** P300 is one of the event-related potentials that arise when an infrequent stimulus appears. Oddball tasks are often used to measure P300. This research attempts to create a game-based oddball task for users to enjoy the tasks. There are several elements in a game. This paper discusses the effects of score, feedback system and background in oddball tasks.

**Keywords:** P300, Oddball Tasks, Score, Feedback System, Background

## 1. Introduction

The authors investigate the degree of dementia from several parameters : age, schooling history, the latency of P300, the task difficulty, and so on [1]. P300 is one of the event-related potentials (ERPs) that arise 300 ms after an infrequent stimulus appears [2] [3]. In this paper, the latency of P300 is the time from the stimulus appearing to the peak of P300, and the amplitude of P300 is the potential value (Fig.1).

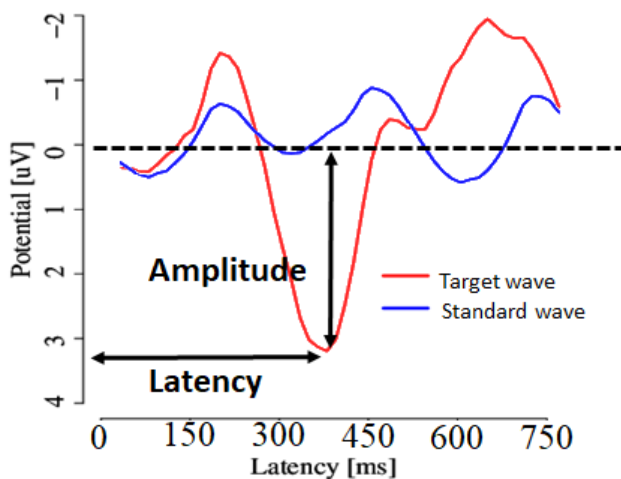


Fig. 1 Latency and Amplitude of P300

Oddball tasks are often used to measure P300. These tasks are those in which infrequent stimuli appear in frequent stimuli to induce P300. We can observe a user’s P300 with an electroencephalograph (EEG) while he/she attempts oddball tasks. P300 is

observed clearly when a user concentrates the stimuli by counting the number of infrequent stimuli or pushing a button when an infrequent stimulus appears. The authors used an oddball task with yellow circles (Fig.2), although there are various oddball tasks [4]. A large circle is a frequent stimulus (standard stimulus), and a small circle is an infrequent stimulus (target stimulus). There are three types of target stimuli, whose radius ratios are 90%, 70%, and 50% to a standard stimulus. Also, users are requested to push a button when a target stimulus appears. The task difficulty is the radius ratio of the target stimulus because it is easier to push a button as the difference between the radius of target stimulus and that of standard stimulus is larger.

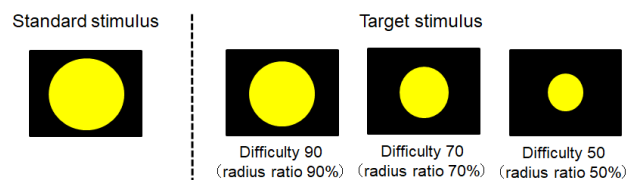


Fig. 2 Stimulus in Oddball Tasks

However, conventional oddball tasks are too monotonous; hence, users often feel bored and the amplitude of P300 gets smaller [5] [6]. For this reason, this research attempts to create a game to measure P300. There are several elements of games (score, feedback system, BGM, sound effect, and background) [7], and it is difficult to discuss the effects of all elements at the same time. Thus, this paper discusses the effects of score, feedback system, and background, which are some of the many elements mentioned above.

## 2. Proposed Tasks

### 2.1 Oddball Task with Score

Score is introduced for users to have a goal. “Rank” is determined according to the total score, and the goal is “getting the best rank.” Score is calculated by subtracting the time until pushing a button from 1400 ms (the sum of stimulus-on time

<sup>1</sup> Nagoya University Furo-cho, Chikusa-ku, Nagoya, 464-8603, Japan  
<sup>†1</sup> Presently with Nagoya University  
<sup>a)</sup> koike@cmplx.cse.nagoya-u.ac.jp  
<sup>b)</sup> yoshikawa@cmplx.cse.nagoya-u.ac.jp  
<sup>c)</sup> furuhashi@cmplx.cse.nagoya-u.ac.jp

and stimulus-off time) as 1 point per 1 ms. For example, in the case of pushing a button 500 ms after a target stimulus appearing, the user gets 900 points (Fig.3). A user loses 700 points (=stimulus-off time) if he/she pushes a button after a standard stimulus appearing. Thus a user can get more points by pushing a button more quickly after only target stimulus.

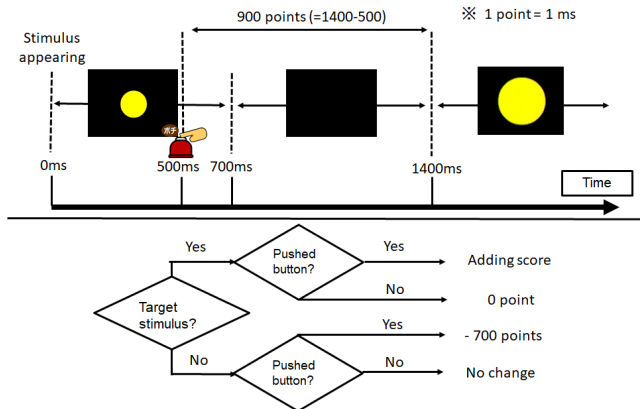


Fig. 3 Oddball Task with Score

**2.2 Oddball Task with Feedback System**

Oddball task with feedback system has the time for a feedback (200 ms). The system indicates “circle” when a user correctly pushes a button after a target stimulus, on the other hand, the system indicates “cross” when a user incorrectly pushes a button after a standard stimulus or does not push a button after a target stimulus (Fig.4).

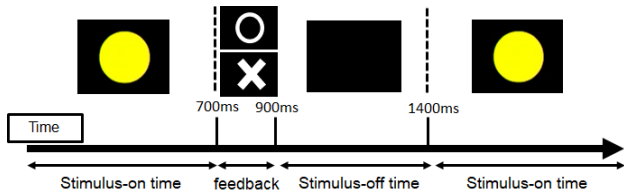


Fig. 4 Oddball Task with Feedback System

**2.3 Oddball Task with Changed Background**

In this paper, the oddball task with yellow circle and black background (Fig.2) is called the conventional background task, and that with yellow circle and game style background is called the proposed background task. The game style background uses “Super Mario Brothers ©1985 Nintendo” because aged people know the game well and the action of the character matches a game-based oddball task.

**3. Outline of Experiment**

**3.1 Oddball Task with Score and Feedback System**

This experiment was carried out to measure P300 by the conventional and the proposed oddball tasks. The subjects included 12 male college/graduate students. The wireless living body measurement machine Polymate Mini made by Miyuki Giken was used as the electroencephalograph. The position of the electrode was “Pz,” with “A1” and “A2” as the base in 10-20 methods [8].

The sampling frequency was 1000 Hz. The interstimulus interval was 1400 ms (stimulus-on time : 700ms; stimulus-off time : 700 ms). The number of target stimuli was 22, and that of standard stimuli was 88 as a set. A subject had three sets of the proposed tasks (see Fig.2), and three sets of the conventional task. The order differed between subjects. The evaluation method was a rating scale method to evaluate the user’s interest. Subjects answered the questionnaire (Fig.5) after each set. Brainwaves were passed through the band pass filter (1-5 Hz) and used 700 ms after the stimulus appeared. The latency and amplitude of P300 were evaluated from the user’s arithmetic mean waveform. Arithmetic mean waveforms are waves that cancel noise by averaging the same condition waves. It is expected that the latency will not change the values. On the other hand, the amplitude should be large, because the value becomes large when a user concentrates on a task [9] [10].

	Very	rather	a little	not either	a little	rather	Very	
Not Concentrating	1	2	3	4	5	6	7	Concentrating
Not Tired	1	2	3	4	5	6	7	Tired
Not Enjoying	1	2	3	4	5	6	7	Enjoying
Not Boring	1	2	3	4	5	6	7	Boring

Fig. 5 Questionnaire used in the experiment

**3.2 Oddball Task with Changed Background**

This experiment was carried out to measure P300 by the conventional and proposed background tasks. The subjects included 10 aged people, 79.5 year-old on average. The interstimulus interval was 1000 ms (stimulus-on time : 500ms; stimulus-off time : 500 ms). A subject had three sets (the difficulty 50 conventional task, the difficulty 70 conventional task, and the difficulty 70 proposed task), and the order of sets was fixed. The other conditions were the same with 3.1.

**4. Result of Experiment**

**4.1 Result of the Rating Scale Method**

**4.1.1 Oddball Task with Score**

The results are shown in Fig.6. The results showed that scores of “concentrating,” “not tired,” “enjoying,” and “not boring” in tasks with score were better than those in tasks without score. The paired t-test for the four ratings indicates that there are significant differences in the three ratings of “concentrating,” “enjoying,” and “not boring” (each of them :  $p=7.31 \times 10^{-4}$ ,  $p=1.25 \times 10^{-7}$ ,  $p=2.83 \times 10^{-9}$ ). The significance level is 0.003 (=0.05/18) using the Bonferroni method because there are 18 t-tests (there are 12 t-tsets in results of the rating scale method and 6 t-tests in results of brainwaves in this paper).

**4.1.2 Oddball Task with Feedback System**

The results are shown in Fig.7. The results showed that scores of “concentrating,” “enjoying,” and “not boring” in tasks with feedback system were better than those in tasks without feedback system. The paired t-test for the four ratings indicates that there

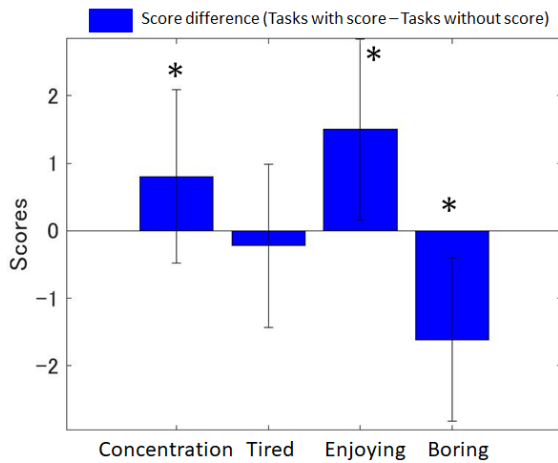


Fig. 6 Scores of all difficulty w/ and w/o score

are significant differences in the two ratings of “enjoying,” and “not boring” (each of them :  $p=1.44 \times 10^{-5}$ ,  $p=2.00 \times 10^{-3}$ ).

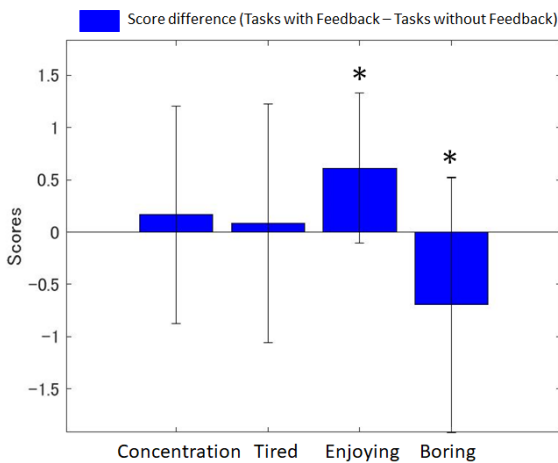


Fig. 7 Scores of all difficulty w/ and w/o feedback system

#### 4.1.3 Oddball Task with Changed Background

The results are shown in Fig.8. The results showed that scores of “concentrating,” “enjoying,” and “boring” in the proposed background task were better than those in the conventional task. The paired t-test for the four ratings indicates that there are no significant differences in the all ratings (each of them :  $p=2.9 \times 10^{-2}$ ,  $p=0.69$ ,  $p=8.9 \times 10^{-2}$ ,  $p=0.55$ ).

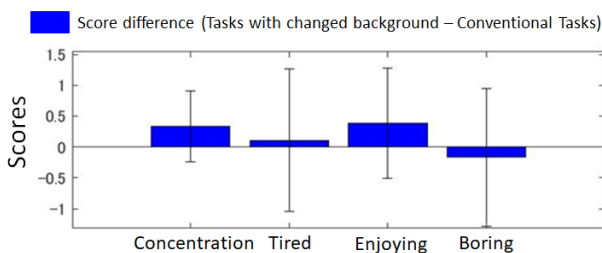


Fig. 8 Scores of difficulty 70 of proposed and conventional background tasks

## 4.2 Result of Brainwaves

### 4.2.1 Oddball Task with Score

The latency and amplitude of P300 are shown in Fig.9. There are no differences between the two tasks. The paired t-test for two values (latency and amplitude of all difficulties) indicates that there are no significant differences (each of them:  $p = 0.05$ ,  $p = 0.51$ ).

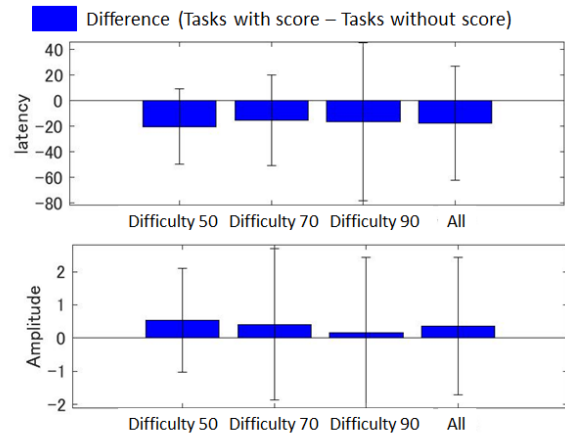


Fig. 9 Latency and amplitude w/ and w/o score

### 4.2.2 Oddball Task with Feedback System

The latency and amplitude of P300 are shown in Fig.10. There are no differences between the two tasks. The paired t-test for two values (latency and amplitude of all difficulties) indicates that there are no significant differences (each of them:  $p = 0.33$ ,  $p = 0.48$ ).

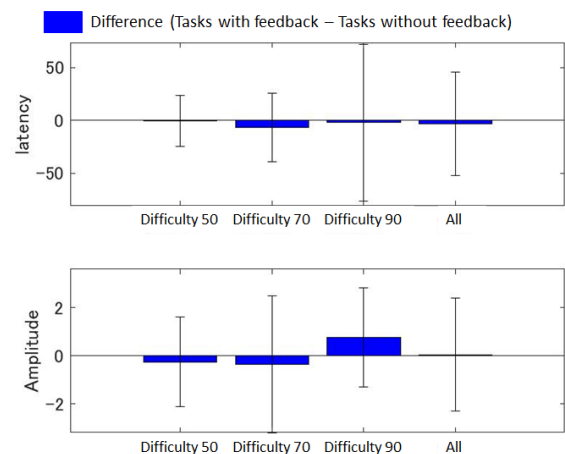
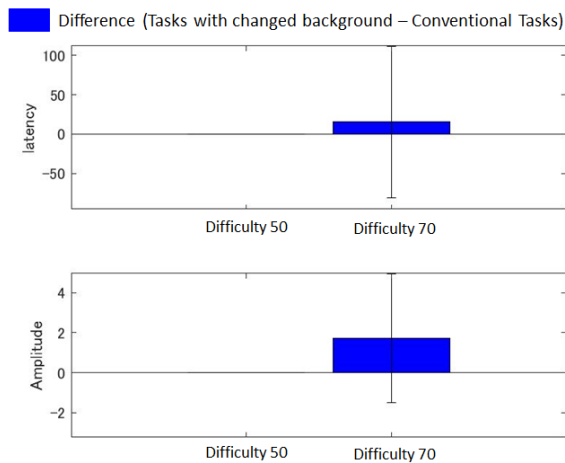


Fig. 10 Latency and amplitude w/ and w/o feedback system

### 4.2.3 Oddball Task with Changed Background

The latency and amplitude of P300 are shown in Fig.11. There are no differences between the two tasks. The paired t-test for two ratings (latency and amplitude of difficulty 70) indicates that there are no significant differences (each of them:  $p = 0.44$ ,  $p = 8.4 \times 10^{-2}$ ).



**Fig. 11** Latency and amplitude with task whose background changed and conventional task

## 5. Examination

### 5.1 Examination of the Rating Scale Method

In the experiment of oddball task with score, there were significant differences in the three ratings of “concentrating,” “enjoying,” and “not boring.” In the experiment of oddball task with feedback system, there were significant differences in the two ratings of “enjoying,” and “not boring.” Users can enjoy oddball tasks more without feeling tired or boring when the tasks have “score” or “feedback system” comparing with the simple oddball task.

On the other hands, there were no significant differences in all of the ratings in the experiment of oddball task with changed background. The following discusses the reasoning behind the subjects’ opinions. Almost all of opinions were “There are little differences between two tasks.” Moreover, some of the subjects did not know the game, “Super Mario Brothers ©1985 Nintendo.” In this experiment, subjects were around 80 years old. It subjects are 60 years old or less, the result will be different because they may know this game. On the other hand, two subjects said that it was easier for them to do the proposed task than the conventional task because they were tired in eyes with looking yellow circle and black background, which is not because of the game style background. In addition to that, it must be a problem to fix the order of tasks. The subjects felt more tired in the proposed tasks done in the last set. Re-experiment is needed because there are some problems in this experiment.

### 5.2 Examination of Brainwaves

There were no differences between each comparison of the two tasks. Latency is related to how fast subjects recognize a target stimulus. Whether tasks have elements of game or not has no relation to the stimulus; hence, there were no differences in latency. Amplitude is related to the concentration of the user. In the rating scale method with and without score, there was significant difference in the rating of “concentration,” so it is expected that the amplitude of the task with score was larger than without score. However, the amplitude of the two tasks were similar. It might need more concentration to make amplitude bigger, and it will be

able to be achieved by adopting all elements of games.

## 6. Conclusion

This paper discussed the effects of “score,” “feedback system,” and “background” in oddball tasks. The following results were found. There were significant differences in the two ratings of “enjoying,” and “not boring” in the rating scale method with “score” and “feedback system.” On the other hands, there were no significant differences in all of the ratings in the rating scale method with changed “background.” Re-experiment is needed because there were some problems in the experiment for the study of effects of background. There were no differences in the latency and amplitude of P300 in all tasks with elements of games.

In future research, a game-based oddball task that helps users enjoy the task will be created.

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