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The brain rhythm related to the music preferences and the detection of the preference

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Abstract– The feature of the brain rhythm (electroencephalogram; EEG) related to the preferences was studied and whether you can detect the preferences for the excerpts using the EEG features was studied. Previous study showed that the EEG related to the music preferences had been recorded when you scored the preference for the listening music excerpts. However, whether EEG related to the preferences is found during listening to the excerpts was not clarified. In the present study, we characterized EEG features related to the music preferences during listening to the excerpts from 10 subjects. The results found there were EEG features correlated with the excerpt preferences during listening to the excerpts. Therefore, we suggest that there will be EEG features related to the music preferences during listening to the music. In addition, we suggest that EEG features correlated with the music preferences was different dependent on the subjects.

1. Introduction

You often use a music player, when you listen to the music. Recently you can listen to the music using a mobile phone. Handling the music player to listen to the music while driving a car is very dangerous, because you may lose the attention to drive. The attention loss leads to the risk of the car accident. You can control the music player manually. You also need to control the music player when you change the listened music or skip the music. It is difficult for you to control the music player during driving a car. Recently the music player is voice-controlled. However, the voice control does not work due to the surrounding noise. Thus, the voice control is also difficult compared with the manual control. Thus we have to find another way to control the music player. Hence, we propose to use EEG.

Recently EEG-control devices were actively studied [1-3]. EEG is a signal recorded from the human's brain. The researchers have tried to control wheel chairs, robot arms using EEG. Thus you can control a music player using EEG. To control it, we have focused on EEG related to the music preferences.

In the visual preference task, the frontal and occipital theta and gamma rhythms are related [4, 5]. In the music preference task, the parietal beta, and the frontal and occipital gamma rhythms were related. The EEG's were recorded when the subject tried to think the scores for the music preferences [6]. However, it was not revealed that the time course of it. In the present study, we tried to find EEG related to the music preferences during listening to the music and thinking the music preference scores.

2. Methods

2.1. Subjects

Ten healthy male participants (mean age $\pm$ standard deviation (SD), 23.5 $\pm$ 0.85 years) took part in the experiment. All participants are right-handed. The informed consent was obtained from each participant before the experiment.

2.2. Music presentation

The excerpts of the music were selected from Real World Computing (RWC) Music Database [7]. RWC Database includes 30 categories of the music. Before the experiment, participants completed the pre-questionnaire which was on the experience of music instruments, the frequency to listen to music, a favorite tempo, tunes, and the image of each music category. They had to rate the preference on each music category using the linear scale from 1 to 6. Lower score indicated a lower preference for the category.

In a trial in the experiment, the participants were sitting in front of a computer display, and they listened to the excerpts and rated it. There were rest, listening-to-music, thinking, and rate-the-music periods (Fig. 1). Participants conducted 30 trials in a session. The music excerpts were selected from 10 categories decided from the results of the pre-questionnaire. An excerpt was presented for 60 s. After listening to the excerpt, the participant rated its preference in 6 linear scales after the thinking period of 5 s. Thirty excerpts were presented to each participant. The presentation on the excerpts was conducted by Matlab (Mathworks Co., MA, USA) custom software. The presentation order of the excerpts was quasi-random. Among 10 participants, two of them had a biased music preference, and one of them had noisy EEG. Hence, three participants were removed in the EEG analysis.

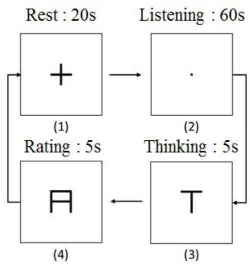

Fig. 1. Time sequence in a trial in the music presentation task.

2.3. EEG recording and analysis

EEG was recorded during a session. Electrooculogram (EOG) was also recorded during the session in order to remove the eye blink artifacts. EOG was monitored with the electrodes located above the right eye and at the lateral to the right external canthus. It was measured by the biological amplifier (Digitex Lab. Co., Ltd. JAPAN). EEG was measured by the amplifier and the DAQ terminal (Intercross Co., JAPAN). Fifteen EEG electrodes (F7, F3, F4, F8, T3, C3, Cz, C4, T4, T5, P3, P4, T6, O1, and O2) were put on the participant's head following the international 10-20 system. Reference electrodes were placed on the left and right mastoid. The ground electrode was put at Fpz. EEG measured by the biological amplifier was filtered between 0.5 and 100 Hz and that by the DAQ terminal was filtered between 0.5 and 250 Hz. They were simultaneously recorded in a PC using the signal recording software LaBDAQ2000 (Matsuyama Advance Co., Ltd., JAPAN) with the sampling rate at 1 kHz.

Blink artifacts were removed from EEG using independent component analysis in EEGLAB [8]. The removed EEG in trials were resampled at 1024 Hz and were divided into the two groups, like- and dislike-groups. The EEG was analyzed using short-time Fast Fourier Transform (sFFT), and the temporal mean powers of theta (4-8 Hz), alpha (8-13 Hz), beta (14-29 Hz), and gamma rhythms (30-100 Hz) were calculated. In addition, the mean powers were calculated during the listening period (60 s), and during the first, and the second half of thinking period (2.5 s each). The mean baseline power from -2 s to 0 s based on the presentation onset was subtracted from the powers. Statistical parametric Welch t test was used comparing the powers in like- and dislike-groups. The level of significant probability was set at $p < 0.05$. Pearson correlation coefficients were also calculated between the powers in each rhythm and the preference scores.

Whether the power of EEG correlated with the preference scores was used as classification features was also studied. The linear discrimination analysis was used to classify the like- and dislike-groups. Featured powers were selected based on the statistical test between the correlation coefficient between the mean EEG power and the preference score. In the preference score, the lower scores belongs to the dislike group, and the higher one does to the like one. The discrimination rate was calculated using leave-one-out cross-validation (LOOCV) in each participant in order to evaluate the discrimination power using the individually trained classifier. In addition, to evaluate whether the individually trained classifier could be applied to the discrimination of the others, the discrimination rate in the leave-one-person-out cross-validation (LOPOCV) was also calculated.

3. Results

During a listening-to-music period, there were EEG powers which have significant difference between like- and dislike-music in 7 participants. During the first half of a thinking period, 6 out of 7 participants had the powers. In comparison with the listening-to-music period, the number of the powers decreased to about a half (Table 1). During the second half of a thinking period, all participants had the powers. In comparison with the time for the first half of a thinking period, two participants increased the number of the EEG powers, and six decreased it. In the three periods, the number of the EEG powers which have the significant difference in between like- and dislike-music were the largest in the listening-to-music period (Table. 1). In the average, the number significantly decreased as the time passed (one-way ANOVA, ***$p<0.001$).

Table. 1. The number of the EEG powers which are significantly different between like and dislike music during each period.

Participants	Listening period	The 1st half of thinking period	The 2nd half of thinking period
1	37	8	18
2	36	0	10
3	51	43	33
6	50	25	8
7	45	20	17
8	45	17	10
9	50	35	29
Average	44.9	21.1	17.9
S.D.	5.7	13.7	9.1

During the listening-to-music period, 7 participants have the common EEG powers which were significantly different in between like and dislike music. They were F4 theta, C3 beta, Cz beta, P4 theta, alpha, and beta, and O1 theta and alpha (Fig. 2). However, during both in the first and the second halves of a thinking period, there were not the common regions.

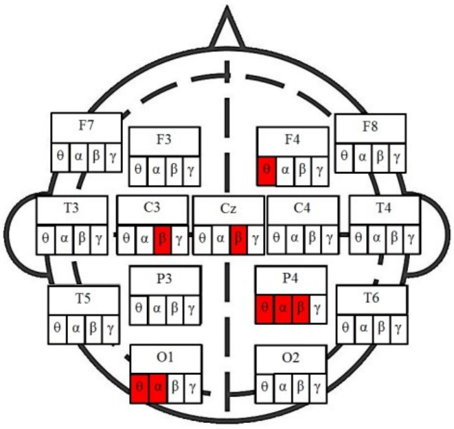

Fig. 2. EEG powers which had the significant difference between like and dislike music for a listening-to-music period observed commonly in all participants. This and the following figures show the top view of the participant's head.

Pearson's correlation analysis indicated that 6 out of 7 participants had the significant correlations between EEG powers and the music preference scores. However, there is no common EEG power which has the correlation in the listening-to-music, the first and the second halves of a thinking periods among all participants.

Then we calculated the correlation between all participants' EEG powers and the music preference scores. There was no EEG powers which have the significant correlation in the listening-to-music period. However, in the first half of a thinking period, there were EEG powers which had significant correlations. The powers were F3 theta, F4 theta, alpha, and beta, F8 theta and beta, C3 alpha, Cz alpha and beta, C4 alpha, T4 alpha, T5 theta, alpha, and beta, P3 theta alpha and beta, P4 alpha and beta, T6 alpha, O1 theta, alpha, and beta, and O2 alpha and beta (Fig. 3). In the second half of a thinking period, the correlated EEG powers were F7 theta and alpha, F3 alpha, F4 theta, C3 alpha and beta, Cz alpha and beta, C4 alpha, T4 alpha, T5 theta, alpha and beta, P3 theta, alpha and beta, P4 theta, alpha and beta, T6 theta, alpha and beta, O1 theta, alpha and beta, and O2 theta, alpha and beta, (Fig. 4).

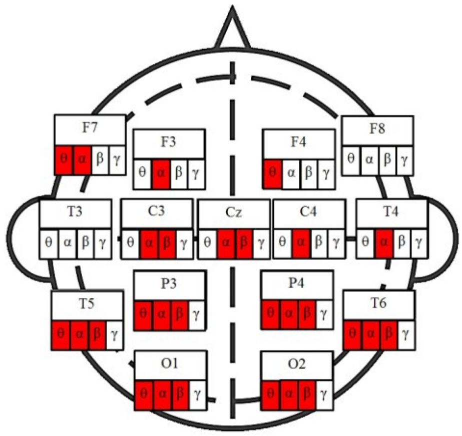

Fig. 3. EEG powers had the significant correlations with the music preference scores in the first half of a thinking period commonly seen in all participants.

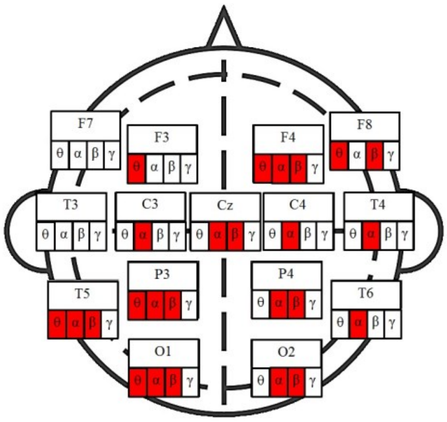

Fig. 4. EEG powers had the significant correlations with the music preference scores in the second half of a thinking period commonly seen in all participants.

Finally we calculated the discrimination score using the EEG power feature in an individual. In average within a participant, the discrimination rate during a listening-to-music period was the highest than the other periods (Fig. 5). The discrimination rate in LOPOCV was a little higher in the first half than in the second half of thinking period (Fig. 6).

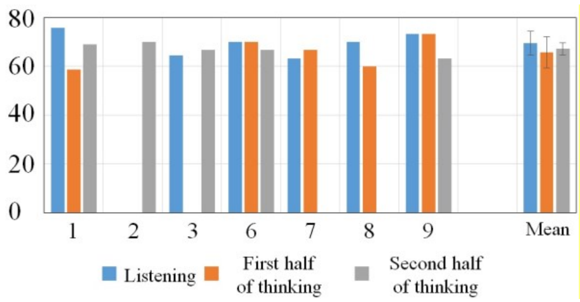

Fig. 5. The discrimination rate calculated by LOOCV in each participant.

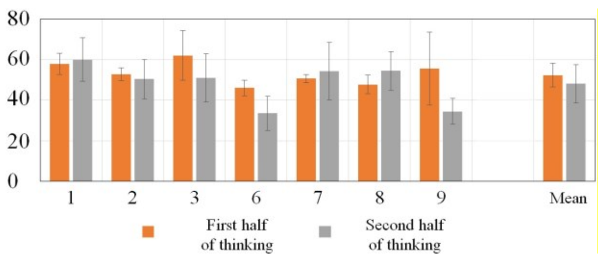

Fig. 6. The discrimination rate calculated by LOPOCV in each participant. There is no correlation in a listening-to-music period using all participants' data. Hence the rates were calculated in the other periods.

4. Discussion

We found previously that there were EEG powers which have the significant difference between like- and dislike-music in a thinking period [6]. In the present study, there was also the significant difference for the EEG powers in a listening-to-music period. In addition, the study showed the significant correlation between EEG powers and the music preference scores in a thinking period. Therefore, it is suggested that there are EEG powers related to the music preferences in listening-to-music and thinking periods.

The result revealed that there was the largest number of the regions which has the significant difference between in like- and dislike-music in a listening-to-music period (Table 1). The number gradually decreased. In a trial, a brain has to process the incoming sound, and finally judge the preference for music. In the process, the size of the area in a brain gradually may decrease.

Previous study showed that left parietal gamma power was significant higher when the excerpts was considered as dislike music [6]. In the present study, we found that some participants had the negative correlation at P3 gamma. However, all participants did not have the negative correlation. The result suggests that there is a possibility that EEG related to the music preferences differ dependent on the individuals.

Each participant had the EEG powers which have the significant correlation with the music preference scores during a listening-to-music and a thinking period. The regions were dependent on the individuals.

The means of the discrimination rate within a participant in LOOCV were over 65%. In addition, the means among participants in LOPOCV were less than those in LOOCV. The result suggests that for detecting the music preference from EEG, we will have to create the individual classifier suitable for the user.

When the participants listened to the self-selected music, beta rhythm is induced [9]. Beta rhythm was also observed in the present study when the participants listened to the music. Beta rhythm may be involved in the process for the music.

In the visual preference task, theta from the frontal to central, and theta at the occipital area and the gamma at the frontal and parietal areas are involved [4, 5]. In the present study, those rhythms were included in Figs. 4 and 5. Hence, those EEG's will be related to the process for the preferences irrespective of the input modalities.

Acknowledgments

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