LETTER

Evaluation of EEG Activation Pattern on the Experience of Visual Perception in the Driving

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SUMMARY The brain processes numerous information related to traffic scenes for appropriate perception, judgment, and operation in vehicle driving. Here, the strategy for perception, judgment, and operation is individually different for each driver, and this difference is thought to be arise from experience of driving. In the present work, we measure and analyze human brain activity (EEG: Electroencephalogram) related to visual perception during vehicle driving to clarify the relationship between experience of driving and brain activity. As a result, more experts generate α activities than beginners, and also confirm that the β activities is reduced than beginners. These results firstly indicate that experience of driving is reflected into the activation pattern of EEG.
key words: *EEG, visual cognition, driving skill, driving experience*

1. Introduction

Intelligent Transport Systems is aiming reduction of traffic accidents by developing various types of driving support infrastructures. It is reported that traffic accidents are reduced along with the growth of ITS technologies [1]. In the field of ITS, much technologies are usually developed in terms of improvement of traffic environment and vehicle functions to reduce traffic jam and accidents using latest information, communication, and sensor technologies. To further improvement of ITS technology, it is necessary to understand driver's conditions including brain activities during vehicle driving.

In the vehicle driving, drivers percept and judge traffic situations, and then appropriately operate vehicle. Here, the brain processes numerous information related to those. On the other hand, the strategy for perception, judgment, and operation is individually different for each driver, and this difference is thought to be arising from level of driving skill acquired by experience. It is reported that occurrence of traffic accident during driving is frequent in beginner drivers than more experts [2]. It also indicated that the level of driving skill is crucial factor in driving. To date, several approaches to understanding brain signal processing regarding vehicle driving have been performed in previous study (e.g. [3]–[6]). In those study, the relation between brain activities and driver's distraction during driving are evaluated. Schier evaluated EEG in the driving task and reported that increasing alpha band activity related to less attention activity [7].

While relationship brain activity and driving task is gradually uncovered; however, the effect of level of skill reflecting experience of vehicle driving is still mystery.

In the present work, we measure and analyze human brain activity (EEG: Electroencephalogram) during performing the visual perception in the vehicle driving to clarify the relationship between driving experience and brain activity.

2. Experimental Methods

2.1 Experimental Setup

Figure 1 summarized experimental environment for measuring EEGs and eye movement in the custom made experimental setup. In the experiment, 2 ∼ 3 minutes of driving scenes captured using video camcorder are utilized in the PC display (1920 × 1080). The level of driving skill is thought to be related traffic scene. Therefore, we utilized different three types of driving scenes (Traffic jam, Urban area, and Highway).

16 healthy subjects (15 males and 1 female) aged from 20 to 23 years with having normal vision or corrected to normal with glasses or contact lenses were participated in EEGs measurement. All of subjects has drivers' licenses. In this study, the level of driving skill in the subjects was determined based on the driving frequency due to that perception skill for the driving is accompanied with the frequency of the driving [8]; beginner subjects were categorized based on who drives less than once in every week, and others were categorized as experts. Based on this criterion, there were

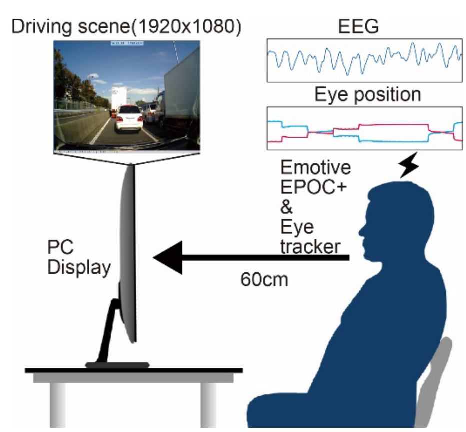

Fig. 1 Experimental setup for measurement of EEG and eye movement.

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eight beginner subjects and eight experts, where the mean number of driving in a week was 0.38 ± 0.17 at beginner and 5.63 ± 0.63 at expert. That indicates that beginners in our subjects have almost no opportunity to drive while experts drive frequently.

In the experiments, firstly the experimental outline was explained for subjects to obtain informed consent. The EEGs and eye movements of all subjects were measured during watching three different driving scenes and a stated of relaxation with closing both eyes for control. The driver's sheet was adjusted for each subject to easily watch the projection monitor. The distance between the projection monitor and a subject is 60 cm and this distance is imitate watching traffic scenes from driver's sheet in the vehicle. In this condition, the field of view is ±30 deg which covers the functional field of view during the driving (~±20 deg) [9]. The experiment was performed in silent condition with using earplug to avoid auditory effects. In the experiment, we asked the subjects to prevent body movement to reduce artifact. After watching each traffic scene, we also asked arousal level. The experimental procedures were approved by the Ethics Committee of Chubu University.

2.2 Measurement of EEG and Eye Movement

EEGs of all subjects were measured using Emotiv EPOC+ (Emotive, CA, US). To record EEG data, the electrodes (14 channels) were placed according to the International 10–20 electrode position systems [10]. When the placement of the electrodes, scalp of subject was cleaned using alcohols to avoid EEG signal deterioration due to scalp oil. The sampling frequency was 128 Hz. In this study, we used EEGs measured from O2 located at the occipital area of the brain for the analysis in terms of consideration of reflection of activity related to visual attention and perception [11], [12], and less noise from eye blinking and eye movement. Eye movements were simultaneously measured using Pupil Lab (Pupil Labs, Berlin, Germany) with a sampling rate of 128 Hz.

2.3 Analysis

Fast Fourier transform (FFT) was used to obtain power frequency spectrum. In the application of FFT, the DC component of EEG data was removed, and FFT was applied for every 1 second with Hanning filter in whole data. Finally, the obtained every power frequency spectrum was averaged. For the depiction, averaged power spectrum was normalized. In the analysis, EEG data including artifact due to eye blink and eye movement was removed.

Recorded horizontal and vertical eye position was calibrated into the size of the traffic scene (0.031 deg = 1 pixel). After removing saccade and eye blinking, we calculated the distribution of horizontal and vertical eye position including pursuit and fixation for each scene, and also computed those standard deviations and skewness.

3. Results

First of all, we evaluated power spectrum during watching driving scene in beginner subjects and experts. Figure 2 illustrates averaged power spectrum in beginner subject (Blue) and experts (Red) in all scenes. We confirmed that the experts generated more alpha band activities than beginner subjects, and also confirmed that the beta band activities were less generated in the experts than beginners. In the all experiment, there were no subjects reporting a decrease in alertness.

Figure 3 summarized alpha band activity (5~12 Hz) of the all subjects in Traffic jam, Urban area, and Highway. In the all driving scene, the larger alpha band activities were observed in experts than beginner subjects. We statistically compared alpha band activity between experts and beginner subjects using Student's t-test, and found significance in all scenes ($p < 0.05$).

Figure 4 summarized beta band activity (12~40 Hz) of the whole subjects in Traffic jam, Urban area, and Highway. In the all driving scene, the smaller beta band activities were observed in experts than beginner subjects. We statistically comparted beta band activity between experts and beginner subjects using Student's t-test, and funded significance in all driving scenes ($p < 0.01$ in Scene-A, $p < 0.05$ in Scene-B and C).

Figure 5 summarized the distribution of eye position

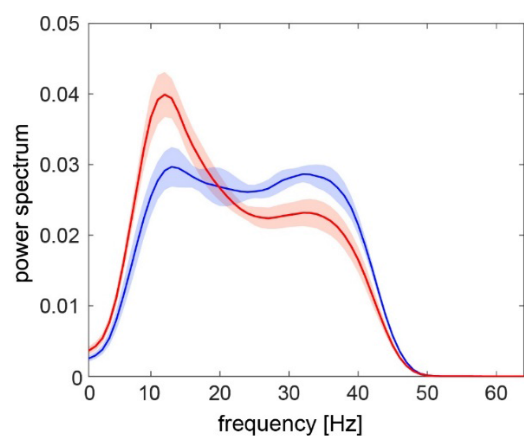

Fig. 2 Power spectrum in the experts (red) and the beginners (blue) during driving scene viewing in the custom made experimental setup. Pale red and blue area indicate ±1SD.

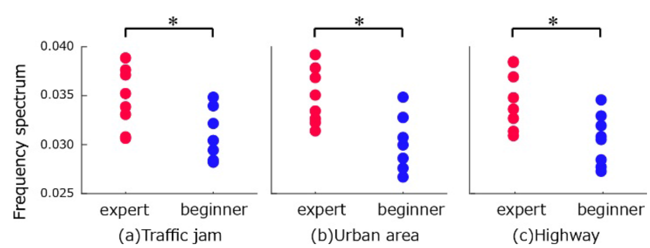

Fig. 3 Alpha band activity of EEG in the experts (red) and beginners (blue). (*: $p < 0.05$)

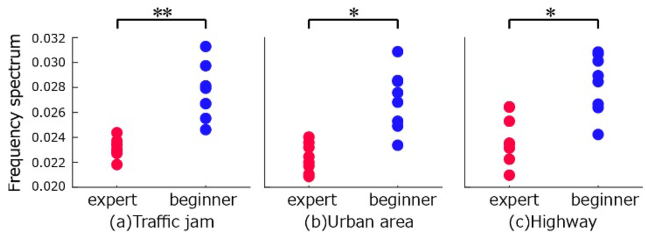

Fig. 4 Beta band activity of EEG in the experts (red) and beginners (blue). (*: $p < 0.05$, **: $p < 0.01$)

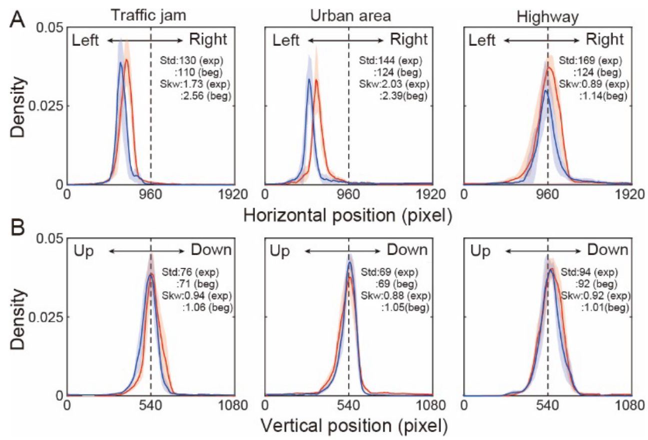

Fig. 5 Distribution of horizontal (A) and vertical (B) eye position in the experts (red/exp) and the beginners (blue/beg) during driving scene viewing. Pale red and blue areas indicate ±1SD. Std and skew in each panel denote standard deviation and skewness.

for beginners and experts during experiments (partly reported in [13]). It is reported [14] that the range of visual search in beginner drivers is relatively narrow than one in experts. Moreover, beginners tend to see the left side of the scene during driving in the urban area. In agreement with this report, the relatively narrower distribution of eye position that especially biased to the left side in the traffic jam and urban area was observed in the beginners than the experts in our experiment. Note that no big difference was observed for the vertical eye position, and also individual difference was not found in our subjects' group as indicated by the small standard deviation for the density of distributions.

4. Discussion and Conclusion

During watching driving scenes, we confirmed that significant lower alpha activity and higher beta activity was observed in the beginner subjects than experts. At these, the distribution of the eye position which was accompanied with the range of visual search was narrower than one for the experts.

It is known that the beta activity is related to concentration. Therefore, beginner subjects considered to be more concentrate on the driving scenes than experts. One of the possibilities of this is that the beginner subjects try to search limited target information such as pedestrians and road signs etc.; as this result, the beta band activities are increased due to concentrating for visual search, also this process reproduces the narrow distribution of eye position as previously reported [14]. Along with the concentration into searching information in the driving scene, the alpha band activity was also decreased in beginner subjects. On the other hand, experts know how to grasping the place to be noticed by experience; therefore, this appropriate strategy in visual perception leads opposite responses in alpha and beta band activity and relatively wider distribution of eye position. From those, we conclude that the experience of perception during driving is reflected into the activation pattern of EEG. Future works will consider the other driving behavior (e.g. pedal and handle work) to investigate the relationship between driving experience and brain activities.

Acknowledgments

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