Effect of Visual Attention and Driving Experiences on the Event-Related Potential P300 in the Perception of Traffic Scenes

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***Abstract*— The numerous objects in the traffic scenes are visually precepted and recognized during vehicle driving. In this process, visual attention is thought to one of the most important functions. It was reported that the traffic accidents are reduced in the drivers having more driving experiences than ones having fewer experiences. It was known that the distribution of the eye movement was varied along with the driving experience in which related that the mechanisms of visual attention also might be changed. Although, the experience alters the visual scan area one of the representation of the visual attention was reported, the detailed mechanisms of visual attention and its related brain signal providing such changes are unknown. In the present study, we focus on the event-related potential P300 which related to visual attention, and investigate the effect of driving experience on the visual attention through the evaluation of the P300 characteristics.**

I. Introduction

The number of traffic accidents is gradually decreased with the recent development and improvement of intelligent transport system (ITS) technologies along with the dramatic growth of technology for artificial intelligence [1]. While this decreasing of traffic accidents, the accidents related to human error such as miss perception and carelessness were still keeping a large portion of the occurred traffic accidents. It is reported that the number of traffic accidents was also decreased with the increase of driving experience [2]. Namely, human-error related traffic accidents are decreased in the drivers who have much driving experiences rather than beginner drivers who have fewer driving experiences.

To date, the effect of driving experience was usually studied by means of the measurement of eye movements (e.g. [3]-[5]). It was reported that the distribution of fixation point was more shifted to the left side in the traffic scenes and was narrower in the beginner drivers than expert drivers [3], [4]. Furthermore, the travel distance of the eye movement of the beginner drivers was longer than that of the expert drivers [5]. Those lines of evidence indicated that the driving experience aid visual functions.

We recently reported that the different EEG activation patterns related to the visual search during the traffic scenes were observed between beginner drivers and expert drivers [6]. Moreover, the gamma band functional connectivity estimated from the EEG recorded from the entire brain was uniquely change in the beginner drivers and the expert drivers [7]. Those also indicate the relationship between driving experience and the brain signal processing on visual perception and recognition. However, what factors effects to those difference of brain activities was still unknown.

In the present study, we focus on the event-related potential P300 due to that one related to visual attention (e.g. [8], [9]) and investigate the response of the P300 based on the drivers' experience. Especially, we experimentally controlled the intensity of the attention of the driver by the instruction and investigate the relationship between an intensity of and driving experience in the perception of traffic scenes.

II. Methods

A. Subjects

The twenty-eight healthy male subjects aged from 20 to 23 years old having a driving license were recruited for the EEG recording for the visual perception of traffic scenes. The subjects also have normal vision or it corrected to normal using glassed or contact lens by the way represented in the driver's license. To evaluate the effect of driving experiences, the subjects were divided into experts and beginners based on the driving frequency and duration of holding a driving license. Based on this criterion, our expert subjects drive more than 2 times per week with more than three years of license holding duration, while the beginner subjects have almost no driving or have less than one year of license holding duration. By this classification, the subjects are divided into 15 experts and 13 beginners. In the experiment, we took the questionnaires for subjects to check fatigues and arousal level, and subjects who reported having fatigue and/or less arousal do not attend the experiments.

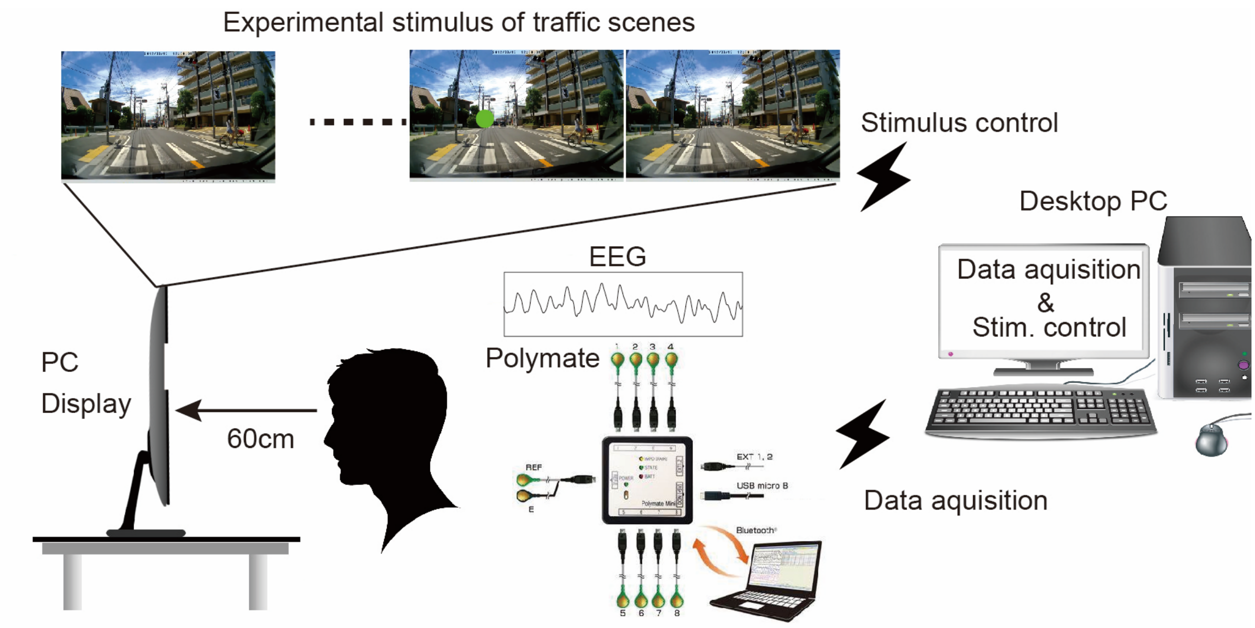

Fig. 1 Experimental environment.

B. *Experimental setup*

Fig.1 illustrates our experimental environments. The experimental environment consists of a PC display (1920x1080 pixel, Dell), a personal computer for the data collection and stimulus control, an adjustable driver's seat and chinrest, and an EEG recorder (Polymate AP108, Miyuki-Giken co. ltd.). In the experiments, the captured traffic scenes were projected onto the PC display. The distance between the PC display and the driver's seat (head of the subject) was 60cm and the field of view in this condition is about ±30 degrees that could cover the previously reported functional view (about ±20 degrees) during vehicle driving [10].

C. *Experimental stimulus and protocol*

We utilized two types experimental scenarios as shown in Fig.2(a): one has the artificial visual target in the captured traffic scenes named stimulus scenario, and another is merely projected the captured traffic scenes named no stimulus scenario. Each scenario has 15 seconds duration including 10 seconds traffic scenes for the task and 5 seconds gray image for resting. In the stimulus scenario, the circular shape of the visual target was presented for 150ms at the center of left side of driving lanes due to using Japanese traffic scenes. The size and color of the visual target were 1.25 degrees of field of view and green, respectively.

In the experiments, we firstly explained the experimental outline for the subjects to obtain informed consent. The EEGs of all subjects were measured during the task mentioned above. The subject sat on the driver's seat and the seat and the PC display were adjusted to a similar visual angle in the vehicle driving. In the experiment, we asked the subjects to prevent body movement to reduce artifacts. After watching each traffic scene, we also asked about arousal.

In the experiment, we divided the subjects into two groups to evaluate the effects of visual attention. Fig.2(b) summarized the experimental procedures for those groups. For the first group, we clearly instruct the detail of the visual target such as color and appearance position preceding the experiment to strongly evoke and fix the attention of the subjects. For another group, we merely instruct the subject to visually search the traffic scenes as the same as ordinal vehicle driving. In the experiment, both groups of subjects watch 30 times for stimulus scenarios and 40 times for no stimulus scenarios those are randomly selected. All methods were conducted according to the Declaration of Helsinki, and the whole protocols were approved by the Ethics Committee of Chubu University.

D. *EEG recording*

The EEGs of all subjects were measured using Polymate AP108 (Miyuki Giken Co. Ltd., Japan). To record EEG data, the electrode was placed according to the International 10-20 electrode-position systems [11]. When the placement of the electrodes, the scalp of the subject was cleaned using alcohols to avoid EEG signal deterioration due to scalp oil. The sampling frequency was 500Hz. In this study, we used EEGs measured from Cz located at the parietal area of the brain for the analysis of event-related potential P300 [8], [9]. During the recording of EEG, the head of the subject is fixed to the chin rest to reduce the noise caused by the body and head movement.

E. *Analysis*

In general, the event-related potential P300 is calculated by averaging around 30 times for EEG response for low-frequency

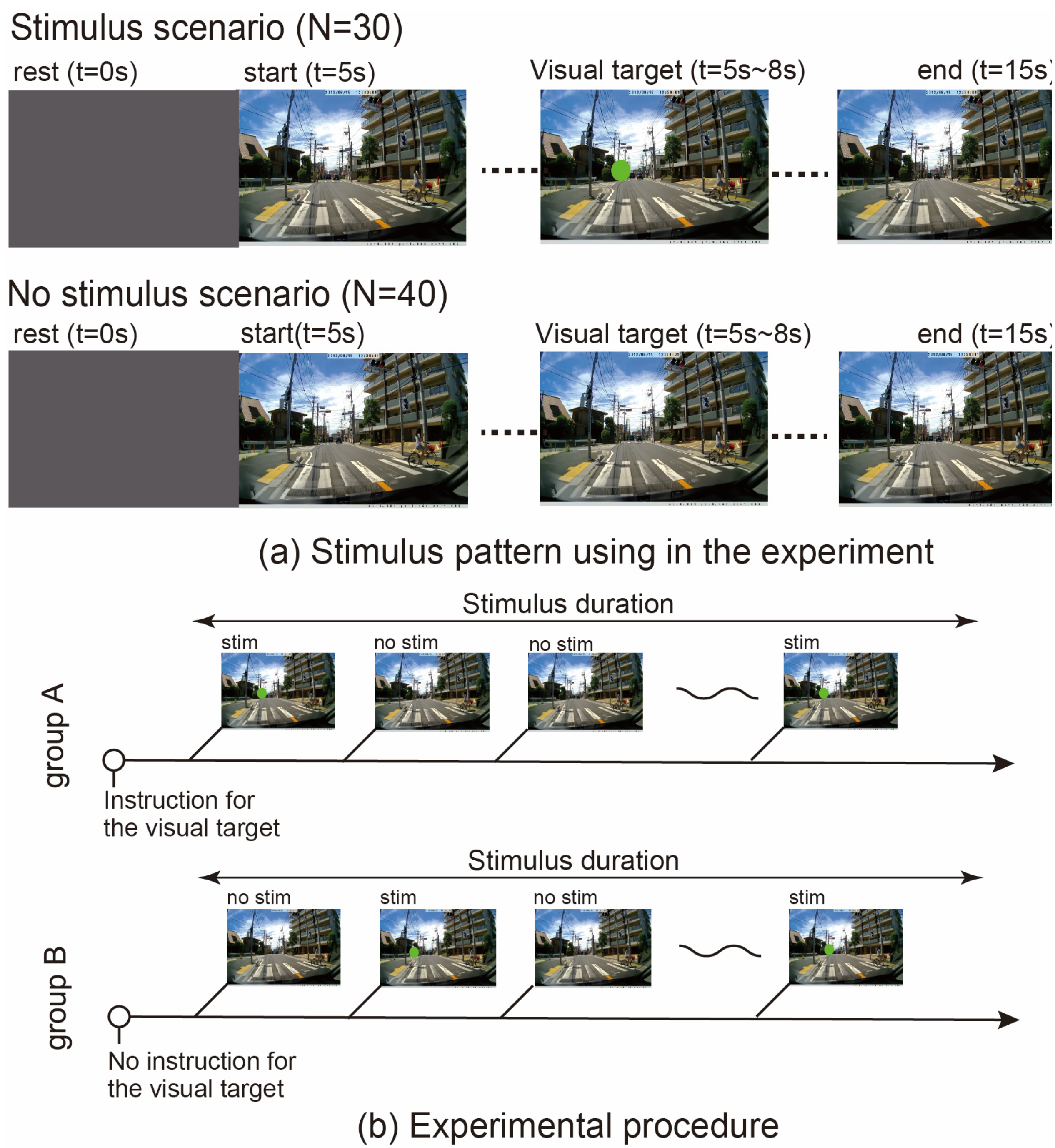

Fig. 2 Stimulus scenario (a) and experimental procedures (b).

stimulus in an oddball task (e.g. [8], [9]). In our experiment, we considered the response for the visual target as the low-frequency stimulus and used it to calculate the P300.

The EEG signal was firstly filtered by a band-pass filter (1Hz to 5Hz) due to that the P300 was mostly observed in the delta band. The filtered EEG between pre -200ms and post 800ms from the onset of visual target appeared is chosen in each stimulus scenarios, then averaged them. To compare this, we also calculate the average response of EEG for the no stimulus scenario by randomly selected 1 second of EEG data from each trial. When the calculation of average, the data including more than three times of standard deviation which computed by each trial is removed due to consideration of noise coming from body movement and/or eye blink.

III. RESULTS

A. *Response of the P300*

Fig.3 summarizes the P300 response in both expert drivers and beginner drivers when the different condition of the bias for visual attention: the visual target was clearly instructed or not. In all conditions, we confirmed that the P300 is observed regardless of instruction for the visual targets or experiences.

Table 1 summarizes the rate for the observation of the P300 in each experimental condition. The rate of the observation for the P300 was calculated by the number of the P300 observed trial divided by total number of stimulus scenarios. When the appearance of the visual target was not instructed, the high observation rate (80.0%) for P300 was observed in the expert drivers while it became very low (33.3%) for the beginner drivers. When clearly giving instruction for the appearance of the visual target to subjects, the observation rate for the P300 is high in both expert drivers (90.0%) and beginner drivers (80.0%).

B. *Rete for the perception of the targets*

Table 2 summarizes the rate for the perception of the visual target in each experimental condition. When the appearance of the visual target was not instructed, an almost similar perception rate was obtained for the expert drivers and the beginner drivers (expert: 65.5%, beginner: 72.6%). When clearly giving an instruction the appearance of the visual target to the subjects, it also elevates the rate for the perception of the visual target in both the expert drivers and beginner drivers (expert: 94.5%, beginner: 96.5%).

IV. DISCUSSIONS

In the present study, we evaluate the effects of driving experiences and the bias of attention controlled by the instruction for the perceptional visual target on the response of event-related potential P300 during the visual perception of the traffic scenes. In the results, the induction rate of the P300 is increased by the instruction for the visual target in both expert and beginner subjects. It was reported the relationship between the event-related potential P300 and attention [8], [9], [12]-[15]and usually, the effect of attention was observed in the amplitude of the peak amplitude of the P300 or latency of for it. In our study, the induction of the P300 is clearly changed by the intensity for the attention which is controlled by the way for the instruction. This phenomenon, extremely related to the intensity of the attention to the occurrence of the P300 is applicable for the perception of traffic scenes during vehicle driving, is firstly demonstrated by our experiment.

The driving experiences are related to the perceptional rate for the visual target rather than the induction rate for the P300 in the present experiment. It was reported that the EEG activation pattern was varied based on the experiences of vehicle driving [6]. Also, the gamma-band functional connectivity estimated from the EEG measured in the perception of the traffic scene was significantly different for the beginner drivers and the expert drivers [7]. Those lines of

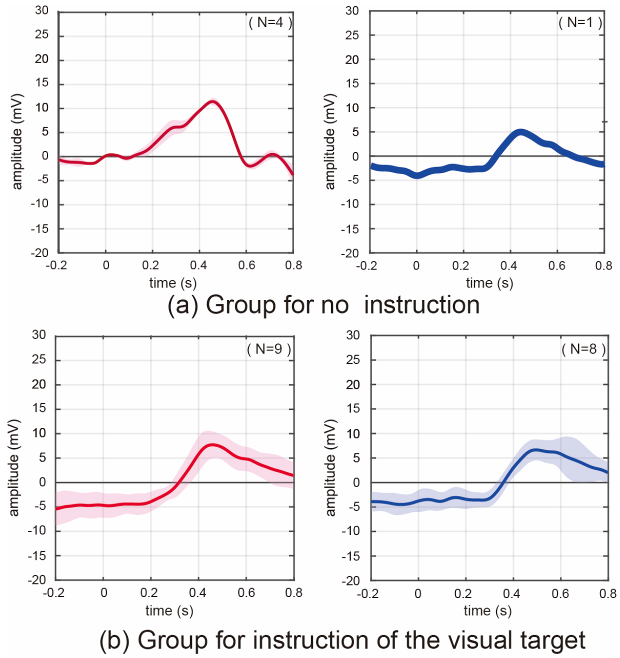

Fig. 3 Response of the P300 obtained from the expert drivers (left) and the beginner drivers (right) in the group of no specific instruction to the visual target and the group having strong instruction to the visual target. Solid line and shaded area correspond average and ±1SD, respectively

Table1 Rate of the observation for the P300 in the expert drivers and the beginner drivers in different condition of the instruction to the visual target.

Condition	Rate of the observation for the P300
beginners with inst.	80.0%
experts with inst.	90.0%
beginners w/o inst.	33.3%
experts w/o inst.	80.0%

Table2 Rate of the perception for the visual target in the expert drivers and the beginner drivers in different condition of the instruction

Condition	Rate of the perception for the visual target
beginners with inst.	94.5%
experts with inst.	96.5%
beginners w/o inst.	72.6%
experts w/o inst.	65.5%

evidence indicate the brain signal processing underlying the visual perception of the traffic scenes was different in the beginner drivers and the expert drivers. In the present study, when the intensity of the attention for the visual target was elevated, the attention-related event-related potential P300 was induced regardless of the driving experiences.

From our study, the strong intensity for the attentional target related to elevating the rate for the induction of the P300 which is related to the attention, and also the increase the perception rate for the visual target. Those imply that the strong attention for the target which is deeply related to the traffic accidents such as the pedestrians and load sign is one of the important factors among the vehicle driving to reduce the number of traffic accidents caused by human error.

V. CONCLUSIONS

The present study demonstrates that the occurrence of the event-related potential P300 is deeply related to the intensity of the attention for the visual target than the driving experiences. In our experiment, the artificial visual target was used as the attentional target. In the ordinal traffic scenes, the intensity for the attention is might be different in the types of target. Therefore, we will investigate the P300 response for those ordinal traffic targets in those drivers is evaluated in the future study.

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