Novel In-Car Environment Control System Using an SSVEP-Based BCI with Visual Stimuli Presented on a Head-Up Display

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Introduction

- While controlling the in-car environment is necessary for comfortable driving experience, it often makes the drivers to neglect to look forward, causing car accidents.
- Steady-state visual evoked potential (SSVEP) [1] is one of the most widely-used brain signals for EEG-based brain-computer interfaces (BCIs).
- In the present study, we proposed an SSVEP-based BCI system to control in-car environment, to help lowering the occurrence of car accidents.

Methods

- ***Participants & Data recording***
  - Total 22 healthy subjects with driver's license (13 males, 24.9yr ± 3.4)
  - Data were recorded from nine electrodes (Cz, POz, PO3, PO4, PO7, PO8, Oz, O1, and O2) using Biosemi ActiveTwo system.
- ***SSVEP stimuli***
  - Four red/green star-shaped checkerboard stimuli flickering at 7.5, 8.57, 10 and 12 Hz were used to elicit SSVEP responses.
  - The visual stimulus was presented via a digital projector on a light reflection film (440*300 mm) attached on a tempered glass panel.
- ***Simulated driving environment***
  - Custom driving map using AirSim open-source platform [2] in Unity 3D
  - The car was controlled via gaming wheel and pedals in simulated environment.

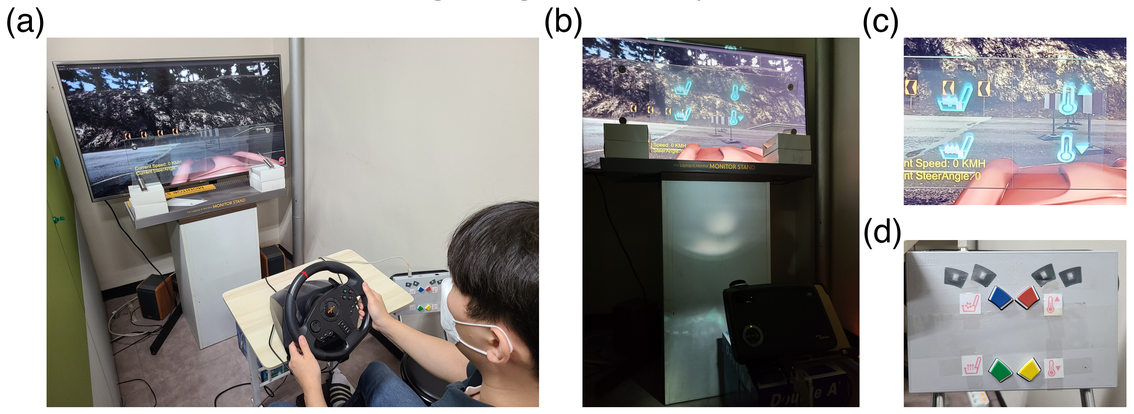

Figure 1. (a) The experimental environment; (b) The head-up display setting employed in the experiment. The visual stimuli were presented on a reflection film via a digital light projector; (c) The visual stimuli; (d) The buttons for manual control.

- ***Driving test #1: Obstacle avoidance***
  - The participants had to stop the car as soon as possible when facing obstacle.
  - Driving performance measure
    1) reaction time (the time elapsed to brake the car upon appearance of obstacle)
    2) no response rate (the ratio of the obstacles that the driver did not respond among all obstacles)
- ***Driving test #2: Car-following***
  - The participants had to follow a preceding vehicle that ran at a sinusoidal speed profile.
  - Driving performance measure
    1) trajectory difference (the deviation of user-car trajectory from the centerline)
    2) speed difference (the speed lag between the preceding car and user-car)

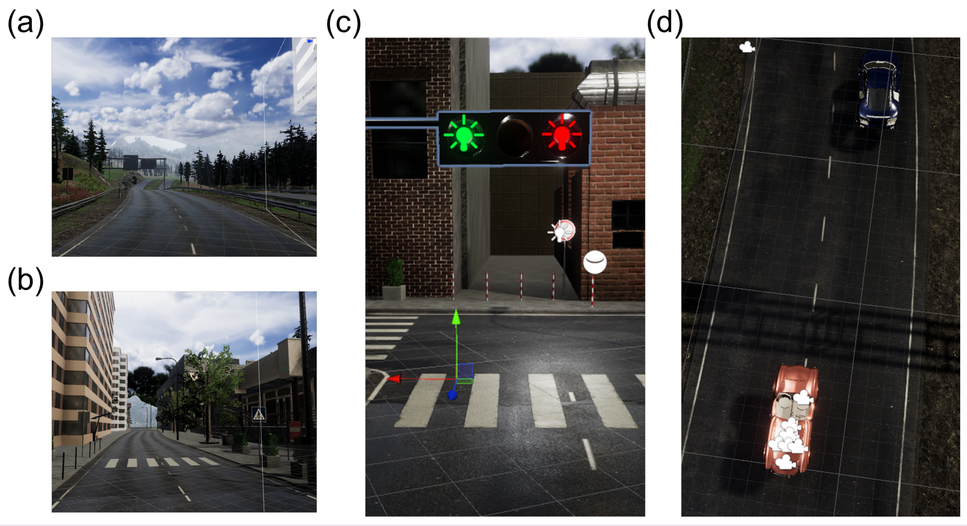

Figure 2. The illustration of simulated driving environment. (a) The highway in the drive course; (b) The in-city driveway in the drive course; (c) An exemplary obstacle in obstacle avoidance session (traffic light); (d) The user-car and preceding car in car-following session.

Results

- ***Control accuracy***
  - SSVEP classification: 82.4%
  - Manual control: 98.3%
  - However, **the driving performance measures were better in SSVEP-BCI control condition**, compared to those in manual control condition.
- ***Driving performance***

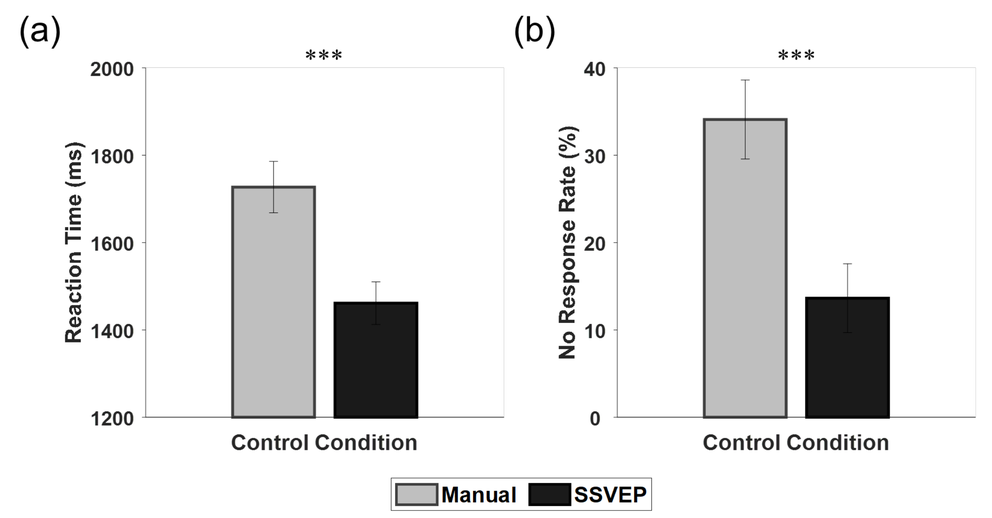

Figure 3. Comparison of the driving performances between SSVEP-BCI and manual control condition in obstacle avoidance session. (a) Reaction time elapsed to brake the car; (b) The rate of the obstacles that the driver did not respond

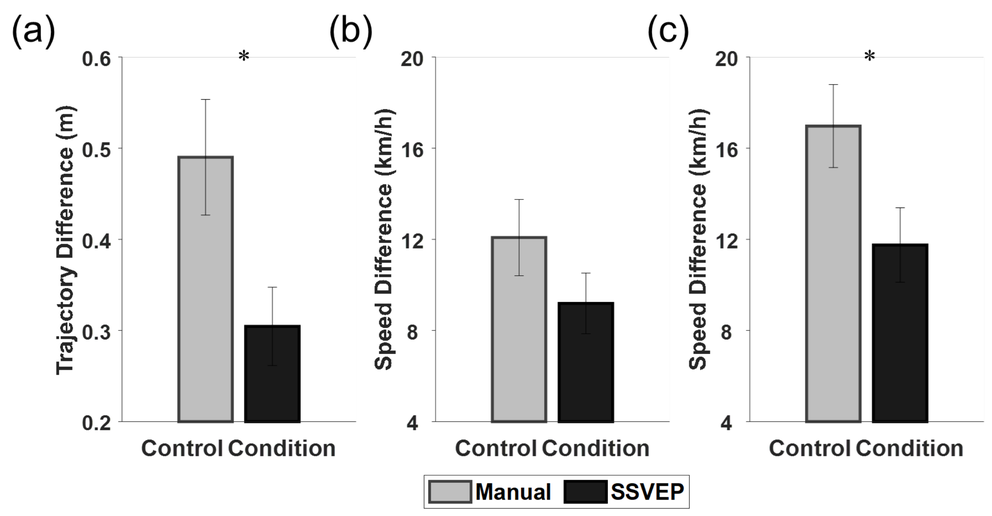

Figure 4. Comparison of the driving performance between SSVEP-BCI and manual control condition in car-following session. (a) Trajectory difference between the user-car and the centerline; (b) Speed difference between the user-car and preceding car; (c) Speed difference between the user-car and preceding car for in-city driving environment

Conclusions

- In the present study, we developed an in-car environment control system using an SSVEP-based BCI with visual stimuli presented on a head-up display.
- In the comparison of the experimental results between SSVEP-BCI and manual control conditions, it has been revealed that the driving performance in SSVEP-BCI control condition were better than those in manual control condition.
- It might imply that the proposed car environmental control system based on SSVEP-BCI could contribute to a safe driving, and consequently lower the occurrence of car accidents.

Acknowledgement

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References

1. Regan, D., "Some characteristics of average steady-state and transient responses evoked by modulated light." *Electroencephalography and clinical neurophysiology,* 20(3), 238-248, 1966.
2. https://microsoft.github.io/AirSim