Introduction

The ability to detect unexpected events and rapidly make appropriate decisions is an essential requirement for safety driving. The neural mechanisms underlying the detection of unexpected events while driving are still poorly understood. Recently, the understanding of the functions in the prefrontal cortex (PFC) has provided some clues with respect to such mechanisms. In particular, the development of near-infrared spectroscopy (NIRS) has provided an opportunity to study human brain activity in a real-world environment. We used NIRS to study the brain activity in PFC under two driving conditions. The present study aims to assess whether PFC is involved in unexpected events and whether cortical activation is sensitive to the repetition of trials.

Method

Subjects

Twenty and twenty-two students at Nagoya University participated in two experimental conditions, respectively.

Materials

The video game ‘The Taxi 2’ was used to present subjects with a simulated driving environment.

Experimental design

Two conditions (Route-fixed and Route-change) were designed. Under the Route-fixed condition, the driving route was fixed on a map, and the task of the subjects was to drive from ‘Start’ to ‘Goal’. In contrast, under the Route-change condition, the subjects drove along a fixed route, and they changed the route immediately after receiving a verbal turning-command.

Procedure

The driving task consisted of six trials. The first two trials were baseline trials with straight driving. The following four trials were experimental trials. Half of them were two times turning (T2), and the other half were four times turning (T4).

A single trial consisted of three periods, i.e. a main task period, a pre-task period (20 s) and a post-task period (20 s). The pre- and post-periods were rest periods, with a black monitor presented to the subjects. The subject practiced operating the game for 180 s before testing commenced.

Apparatus

A 2-channel NIRS unit (PocketNIRS, DynaSense) was used to measure prefrontal changes in oxy-Hb, deoxy-Hb, and total-Hb. Two probes were placed on the left and the right forehead, respectively.

Data analysis

Noise data and the data obtained from left-handed subjects were excluded. Data from 15 subjects under the Route-fixed condition and eighteen subjects under the Route-change condition remained. Baseline correction was applied using the mean during the pre-task period (20 s), and the z-score was calculated using the mean and the standard deviation during the pre-task period. Then we averaged the route-change period (2 s), the pre-change period (2 s) and the post-change period (2 s), respectively, with a 4 s delay.

Results and discussion

A Route (Route-fixed versus Route-change) × period (pre, change, post) × trial (1-4) mixed ANOVA was applied for the left and the right hemisphere, respectively. The results show significant main effects of route and trial for the left hemisphere, and significant main effects of period and trial for the right hemisphere. Interactions between route and period were found for the left and right hemispheres. We conclude that PFC is involved in unexpected events and the first presentation of a salient stimulus has the most significant effect on PFC (Figure 1).

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