 DOI: 10.3217/978-3-85125-467-9-75

Single Trial Classification of Neural Correlates of Anticipatory Behavior during Real Car Driving

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Introduction: Anticipation of events such as changes in traffic light signals and preparing to brake or accelerate are critical behaviors during driving. Smart vehicles, equipped with on-board Brain-Computer Interface (BCI), could decode the driver's intention to perform an action from his brain activity, thus, enable a possibility to enrich the interaction between the car and its driver [1]. We investigated on the existence and single trial detection of neural correlates of anticipatory behavior [2] in response to traffic lights during real world driving. This can be beneficial in the prediction of the driver's movement intention through neural correlates of anticipatory behavior.

Methods and Results: The experiment was conducted on 8 drivers over 2 sessions on separate days. EEG was acquired using 64 electrodes along with two EMG electrodes, placed on the *tibias anterior* muscle of the subjects' right leg. Experiments were performed with an *Infinity Nissan* car on a closed road with 6 traffic lights placed at specific locations. These traffic lights were programmed with a fixed timing (3 s of Yellow). The drivers were instructed press accelerator pedal as soon as they see the Green light and press the brake pedal immediately after the Red light. The EEG signal was filtered using the weighted average filter (WAVG) to reduce the spatial noise, then spectrally filtered in the range of [0.1 1] Hz [1]. Cz potentials at 4 equally spaced time-points during the last 2 s before each cue has been considered as the features. The EEG grand averages shows that a negative slope starts around 1 s after Yellow light and peaks around the onset of Green/Red light (see Fig. 1), similar to those observed in closed classical CNV paradigm [2]. For the single trial classification, we relied on QDA classifier with 4 fold cross-validation method and evaluated using the AUC in the ROC space. The average AUC, across 2 recording days, of the 0.63±0.08 for accelerating and 0.64±0.13 for braking has been achieved in an offline analysis. Notably, 4 subjects reached an AUC of 0.70.

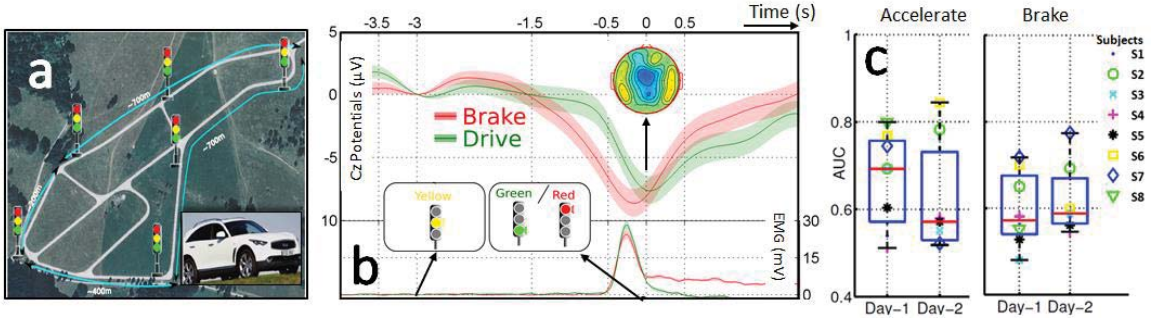

Figure 1. *(a) The map of closed road, inset is Nissan Infiniti vehicle. (b) Grand averages of Cz potentials (shadow represent the standard deviation) and EMG envelopes. Topographic representation of average EEG scalp distribution at t=0 s (the onset of the appearance of Green/Red light).(c) The AUC for Accerelate (Drive) and Brake.*

Discussion: We confirmed the existence of the anticipatory Slow Cortical Potentials (SCPs) in response to traffic lights. Remarkably, we have demonstrated a possibility of detecting these potentials in real world driving, despite large amounts of visual distractions and movement artifacts.

Significance: This study shows, for the first time, the possibility of detecting the anticipatory SCPs in response to traffic lights during real world driving. This will be beneficial for building in-car BCI systems to predict driver's intended action through anticipatory brain potentials. Such BCI systems can provide information in order to achieve the assistance in-line with the driver's intention.

Acknowledgements: The work was supported by Nissan Motor Co. Ltd., under the project 'Research on Brain Machine Interface for Drivers'.

References

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