Prefrontal activity during driving in young adults

Ranchet, M[1], Derollepot, R.[1], Villa, C.[2], Ndiaye, D.[2], Moreau, F.[1], Bremond, R.[2], Fort, A.[1,]

[1]TS2-LESCOT, Univ Gustave Eiffel, IFSTTAR, Univ Lyon, F-69675 Lyon, France

[2]COSYS-PICS-L, Univ Gustave Eiffel, IFSTTAR, F-77454 Marne-la-Vallée Cedex 2, France

Introduction and Aim:

Multitasking (MT) activity may alter driving behaviour, particularly in young adults (for instance, Braitman & Braitman, 2017). To date, few studies have examined cortical activity during MT driving (for a review, see Palmiero et al., 2019). The main objective of this pilot study was to examine cortical activity in cognitive regions in response to driving-relevant visual cues during MT driving as compared to simple driving in young adults.

Methods: Twenty-one participants (age = 32 ± 8 years-old, 15 men) were included in a driving simulator study (Figure 1). They performed 2 single-task conditions (1) simple driving (2) active podcasts listening and 1 MT driving condition (3) driving while actively listening podcasts. During simple driving, participants performed several braking trials: they were instructed to follow a lead vehicle at 70 kmh and brake as soon as braking lights were turned on. During the active listening task, they had to listen podcasts in order to be able to respond to several questions asked just after the scenario. Questions were used to ensure that they were engaged in the listening task. During MT driving, participants were instructed to perform the same braking task as in the simple driving while actively listening podcasts with no priorization given. Each task was repeated 4 times for 2 minutes. Cortical activity in different regions were measured using a 43-channels NIRx system (NIRScout). For the purpose of this study, 4 channels (C1, C2, C22, C23) that recorded dorsolateral prefrontal cortex (DLPFC) activity were analysed together and separately. Figure 1 shows the optodes configuration. The DLPFC plays a major role in executive functions, essential for the management of cognitive functions including planning, working memory and cognitive flexibility. After checking signal quality of all channels, a basic processing stream was applied. The processing stream was conducted as followed: 1) Optical density conversion: conversion of raw data into optical density; 2) Filtering: attenuation of respiration and cardiac activity and high frequency noise with a low pass filter at 0.3 Hertz; 3) Concentration conversion: conversion of corrected optical density data into relative concentration changes using the modified Beer-Lambert law. Values of differential path length factor (DPF) was set at 6; 4) Event-related hemodynamic responses were analysed using relative changes in HbO_2 from the 2 seconds before to 7 seconds after the trial. All trials were averaged per condition. Behavioural performance included braking performance and the number of correct responses after the listening task.

Results: Young drivers have decreased HbO_2 in the whole DLPFC during MT driving compared to simple driving ($F_{1,20} = 5.07$, P = 0.04, $p\eta^2 = 0.20$) (Figure 2.1). Looking at the channels separately, it seems that this effect is mainly due to one channel located in the right hemisphere (C23: $HbO_{2simple\ task}$: 0.06 ± 0.11 versus $HbO_{2MTdrving}$: -0.04 ± 0.10 µmol/L, $F_{1,20} = 7.87$, p = 0.01, $p\eta^2 = 0.28$) (Figure 2.2). Preliminary results showed that participants braked more slowly to the lead vehicle's braking lights during MT driving than during driving alone. They also responded less correctly after the listening task while driving than during the listening task alone ($p < 0.05$).

Conclusion: This study shows that MT driving has a negative effect on event-related hemodynamic responses. A reduction of event-related cortical activity in the frontal region during MT driving was observed. Furthermore, young drivers had poorer behavioural performance during MT driving compared to simple driving. To better understand the neural mechanisms underpinning MT driving, further analyses in a larger sample size using more channels located in multiple cortical regions are warranted.

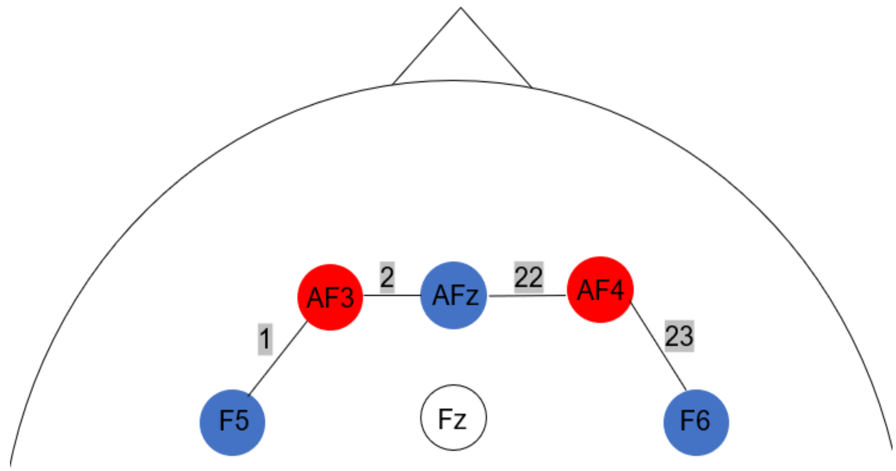

Figure 1. Optodes configuration with respect to the Fz locations of the international 10-10 system. Red circles represent the sources and blue circles represent the detectors. The numbers in gray represent the channels.

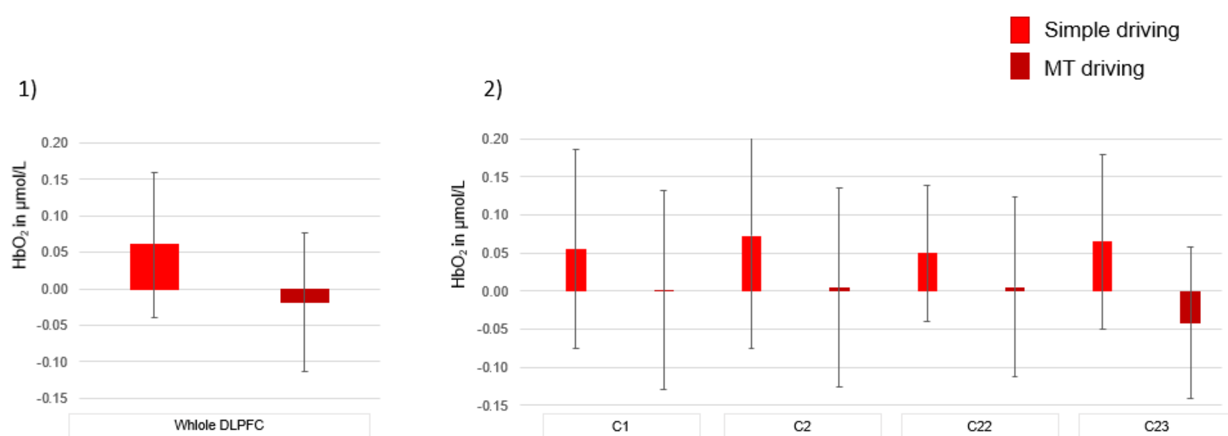

Figure 2. Relative changes in HbO_2 for the whole DLPFC (1) and for each channel (2).

References

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