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Driver cognitive workload estimation through cardiovascular activity: a working memory approach

A.J. Béquet, M. Astier-Juvenon, G. Pépin, C. Gabaude, A.R. Hidalgo-Muñoz

CONTEXT

Dual task realization while driving rises the level of **cognitive workload (CW)** due to the competition with cognitive resources involved in driving

(Patten et al. 2004)

Driving is a task requiring various **working memory (WM)** components. Baddeley's WM model allows to illustrate and disentangle how various levels of CW impact driver cognition.

(Baddeley, 2000)

CW variations while driving can be detected by **ECG**: heart rate (HR) and HR variability parameters such as root mean squared standard deviation (RMSSD) of successive R-R intervals

(Heine, 2017)

OBJECTIVE

- Monitoring driver's CW using ECG parameters and analyzing the links between WM components and HR through incremental difficulty tasks. Complementing results reported in a previous study where evoked cardiac responses were analyzed (Pépin et al., 2017)

MATERIAL AND METHOD

18 participants* (10 males, 22.7 ± 1.4 years). A valid driving license for at least 3 years.

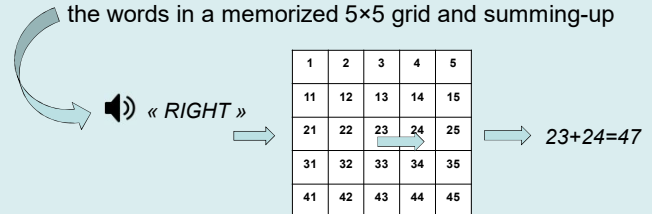
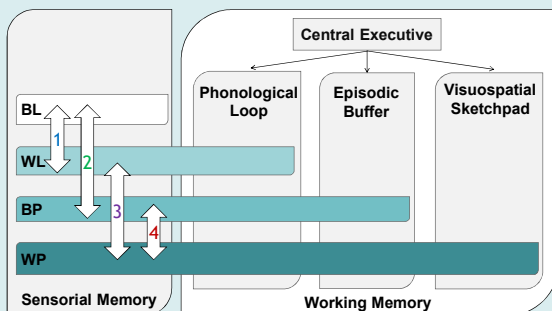
Four **cognitive tasks**, 5-minutes length per condition:

🎧 **Beep Listening (BL)**: Passive listening of beeps

🗣️ **Word Listening (WL)**: Passive listening of direction words

🧠 **Beep Processing (BP)**: Counting of beeps

🗣️ **Word Processing (WP)**: Mental displacement following the words in a memorized 5x5 grid and summing-up



Each condition was performed as 2 types of activity

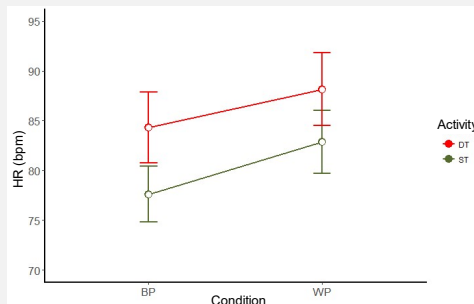
Single Task (ST): cognitive task without driving

Dual Task (DT): cognitive task while driving in a simulator

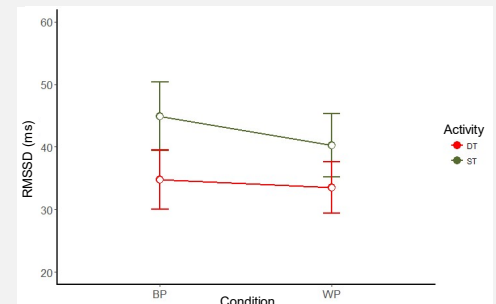
RESULTS

HR: A main effect of driving was found for every comparisons ($p \leq .01$, cf comparisons 1, 2, 3 and 4 above)

RMSSD: A main effect of driving was found only for the comparisons 3 and 4 ($F(1,11) = 8.60, p = .014, \eta^2 = .439$) ($F(1,12) = 14.2, p < .01, \eta^2 = .542$)



- HR increases when CW is higher (between BP & WP), for both ST and DT $F(1,11) = 32.68, p < .001, \eta^2 = .748$



- RMSSD decreases when CW is higher (between BP & WP), for both ST and DT $F(1,11) = 7.99, p = .016, \eta^2 = .421$

*some subjects were excluded in different analyses due to low quality signals

CONCLUSIONS

- Driving increases HR. However, RMSSD is less impacted by driving activity, showing that it could be more specific to high WM solicitations and thus be more robust measure than HR to detect CW
- An additional task to driving, which engages the visuospatial sketchpad (VS), such as under WP condition, generates a supplementary CW due to the competition for the VS

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