

Influence of psychological flow on the management of cognitive secondary tasks while driving

An approach comparing subjective and objective mental effort measurement

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Context

- Driver distraction and driver inattention have been shown to be critical factors in road crashes and near-crashes
- Premise of the ATLAS Project
 - Importance to gain knowledge on driver diverted attention due to internal thoughts
 - An Hospital survey was conducted to estimate the fractions of road accident risk that can be attributed to driver distraction and inattention
 - 10% of accident attributable to driver inattention (Galéra et al, *BMJ* 2012)
 - 8% of accident attributable to driver distraction (Bakiri et al, *AAP* 2013)



➔ Necessity to focus on the influence of internal factors on driving performance



Context



- Various simulator driving experiments were conducted collecting physiological data
- Main difficulties :
 - Dissociation between executive control and effort
 - Influence of various type of cognitive control (attentional control, emotional regulation and behavioral inhibition)
 - Analysis of covert effects
- EEG (Fort et al, *Brain Res.* 2010 & 2012)
- ECG focusing on the distinction between subjective and objective effort



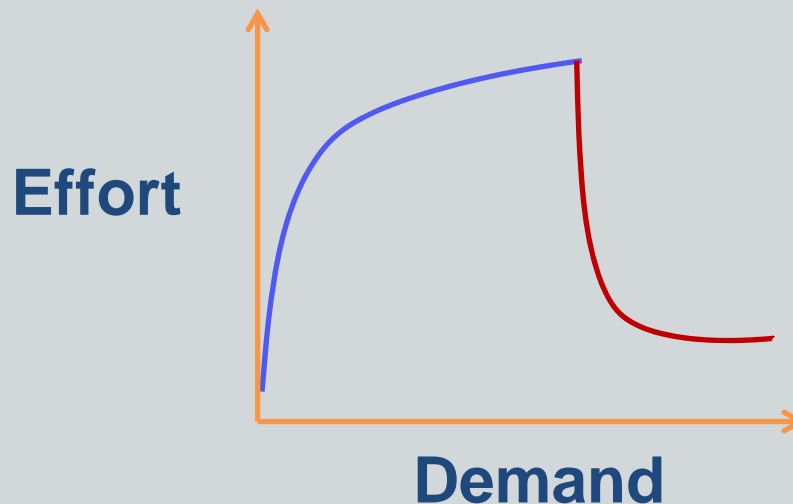
Previous preliminary ECG results 1/2

- **Cognitive load measurement while driving** (Gabaude et al., *HFES* 2012)
 - Driving activity analyzed through video epoch (penalty points for driving errors, secondary task errors, help request, stress signs)
 - Cardiac activity analysis
- ➔ **Various possible modes of autonomic control for Heart Rate**
 - Reciprocally coupled mode between symp. and para symp. activities or not
 - Variations depending on road type and cognitive secondary task (verbal or visuo-spatial)
- ➔ **Subjective and objective efforts (evaluated through HR and HRV) are not correlated**
 - Association or dissociation between subjective and objective effort
- ➔ **Two workload regulation strategies identified**
 - Higher declared workload/overt effects/lower driving performance
 - Lower declared workload/covert effects/better driving performance



Previous preliminary ECG results 2/2

- Effortful and effortless attention
 - Workload is mediated by internal factors such as operator skills and motivation
 - Individual differences in the capacity for effortful and effortless attention



Kahneman (1973)
Wickens (1984)

**Csíkszentmihályi
(1975)**

→ A new hypothesis

The experimental protocol induced a flow state for some drivers



Flow definition (Csikszentmihalyi, 1990)

- Subjective experience of enjoyment and concentration that occurs during challenging tasks matching in difficulty to the person's skill level
- 9 elements of verbalizations of this state
 - Clear goals
 - Challenge-skill balance
 - Action-awareness merging (automatic)
 - Sense of control
 - Unambiguous feedback
 - Loss of self-consciousness
 - Transformation of time
 - Autotelic experience
 - High concentration



Purpose and Hypotheses

- Study the influence of the driver's psychological *flow proneness** on mental effort evaluated by cardiac activity and declared workload

**Flow proneness = tendency to experience flow states*

- Hypotheses
 - The cognitive tasks increase drivers' mental effort
 - Flow proneness will be negatively correlated with declared workload



Material and method

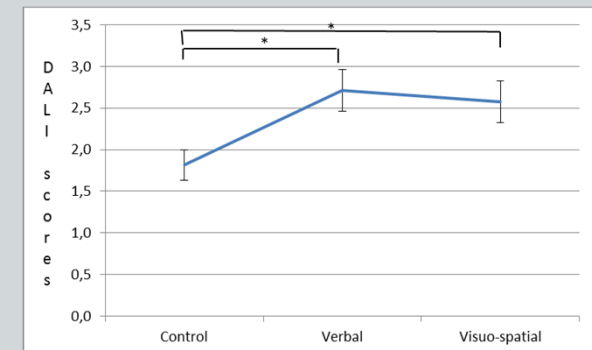


- 24 participants (mean age 26 years old)
- Experimental design: $S_{12} < FP_2 > * C_3 * R_2$
 - 3 simulator driving conditions (C) on two road types (R)
 - Driving only
 - Driving while performing verbal tasks
 - Driving while performing visuo-spatial tasks
 - A French version of the Swedish Flow Proneness (FP) Questionnaire (from Ullen et al, 2012; between subj. var.)
- Dependent variables
 - Declared workload : DALI (Pauzié, 1998)
 - Objective workload measures (5 min period, MP 150 Biopac)
 - Heart Rate
 - Heart Rate Variability
 - Symp. Act. + paraSymp. act. + LF/HF ratio



First results

- Objective mental effort
 - Heart Rate : NS effects (driving condition, road type, flow proneness)
 - HRV: NS effects
 - Sympathetic and parasympathetic activities, LF/HF ratio: a road type effect only: $p=0.009$, $p=0.009$, $P=0.017$ (respectively; higher parasymp. act. on rural road)
- Subjective mental effort
 - Task effect only: $p<0.001$
- Flow proneness influence on effort
 - Negative correlation between the interference dimension of the DALI with Flow Proneness only ($r=-.61$, $p=0.03$)
 - No correlations with objective measures



Discussion

- The cognitive tasks increase declared drivers' mental effort but not the objective effort as it was measured
 - HR and HRV evaluated during a 5 minutes period is not a good indicator of the objective effort (not sensitive enough)
 - Promising research avenue with the Evoked Cardiac response (Lawrence and Barry, 2010)
- Flow proneness seems negatively correlated with declared workload (DALI interference score; to be confirmed on a larger sample)
- Flow proneness measurement is not sufficient, future research should address the trait versus state issue of flow (Flow State Scale, Jackson & Marsh, 1995 associated with objective measure)



Conclusion and perspectives

- Small contribution in the understanding of psychological and physiological transformations while driving → hard work to disentangle both but a necessary step to understand workload regulation strategies
- Criteria for when attention is below a certain threshold have to be established with sensitive workload measurements → new cardiac signal processing technics
- The notion of psychological flow raises new perspectives to make driving less costly at an attention level

This research was supported by an ANR (French National Research Agency) grant (ANR-09-VTT-04)

