

# Towards real-time detection of cognitive effort in driving: Contribution of cardiac measurement

PEPIN Guillaume

Jallais C., Fort A., Moreau F.,  
Navarro J. & Gabaude C.

Humanist Conference,  
Loughborough, UK  
30/06/2016



Humanist

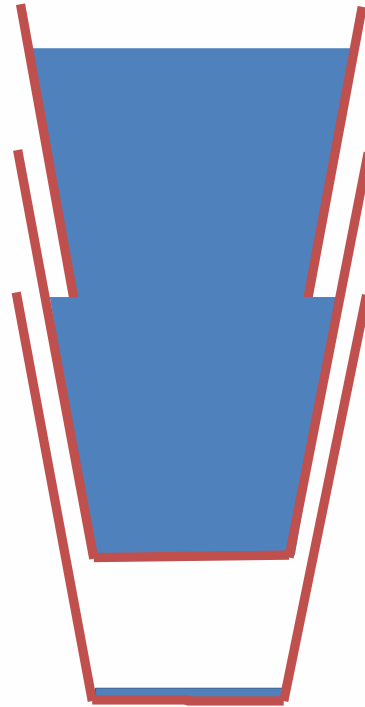


Loughborough  
University



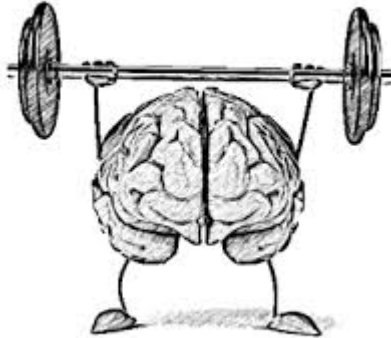
IFSTTAR

# Attentional resources and Driving



# Neuroergonomics Approach

(Parasuraman, 2003)



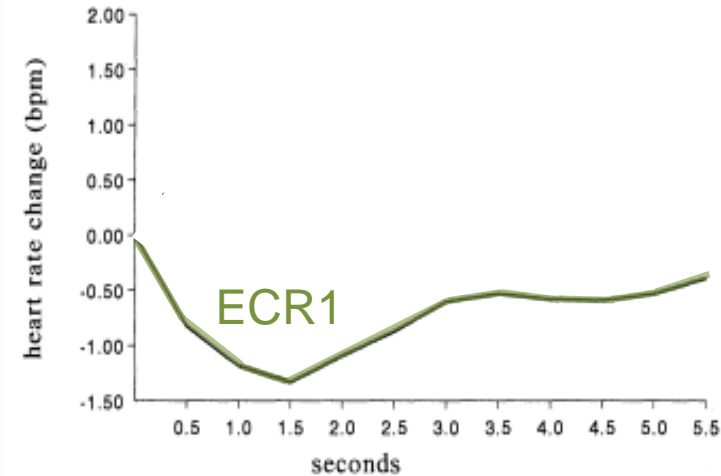
Highlight a cognitive effort indicator suitable for driving to detect drivers' overload



# Heart Rate Change

*Kaiser et al, (1996; 1999)*

- Hearing beeps impact Heart Rate Change (HRC)
  - ➔ ECR1
- Counting beeps impact HRC differently
  - ➔ ECR1 + ECR2



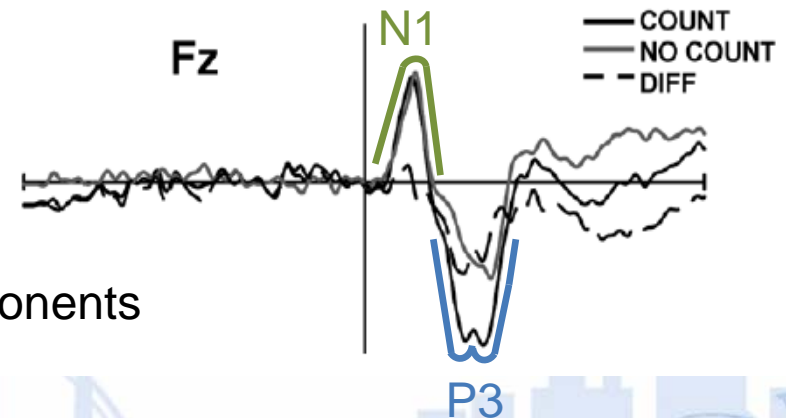
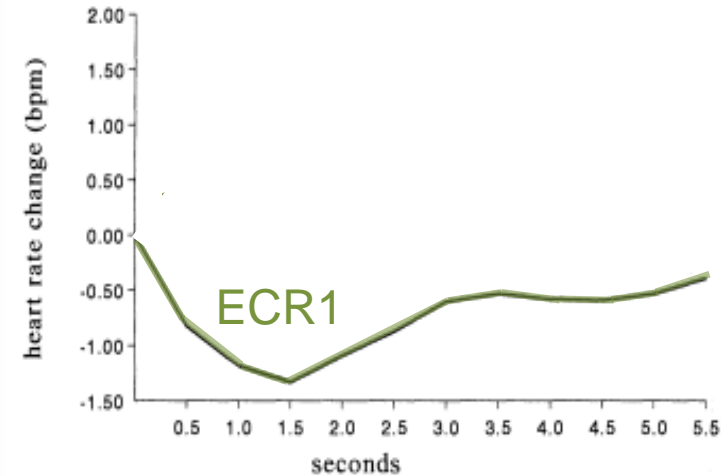
# Heart Rate Change

*Kaiser et al, (1996; 1999)*

- Hearing beeps impact Heart Rate Change (**HRC**)
  - ➔ **ECR1**
- Counting beeps impact HRC differently
  - ➔ **ECR1 + ECR2**

*Lawrence & Barry (2009)*

- Same results : **ECR1 + ECR2**
- Counting beeps also impact Event-Related Potentials (**ERPs**)
  - ➔ **N1** and **P3**
- Cerebral and cardiac pairs of matched components
  - ECR1/N1**; **ECR2/P3**
  - ➔ Possibility to infer ERP from HRC



# Materials & Methods

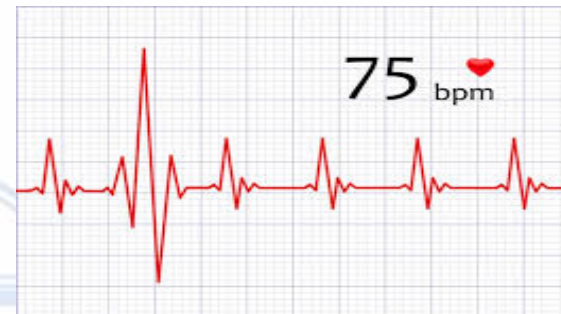
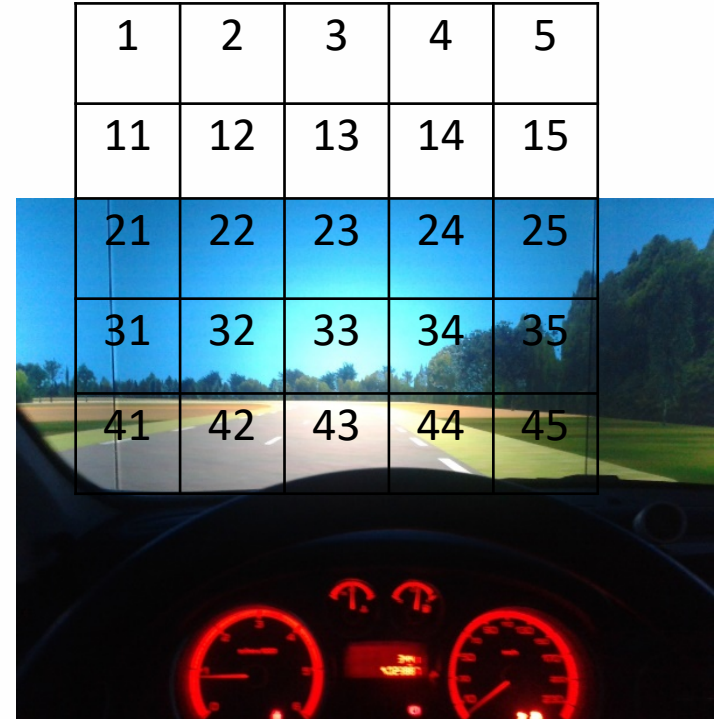
18 participants (age  $22,7 \pm 1,4$ ), 10 males

## 3 Within-Subject Factors ( $2^3 = 8$ conditions)

- *Cognitive Activity*: Active vs Passive
- *Difficulty level*: Easy vs Difficult
- *Task*: Simple vs Dual

## Material

Driving Simulator, BioPac MP150 to collect Heart Rate (HR)



# Preprocessing

## Signal Measurement

- $IBI_n = r_n - r_{n-1}$

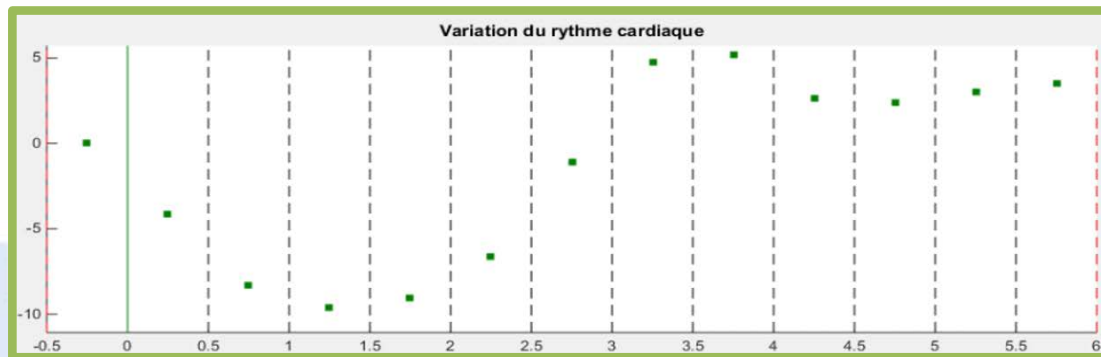
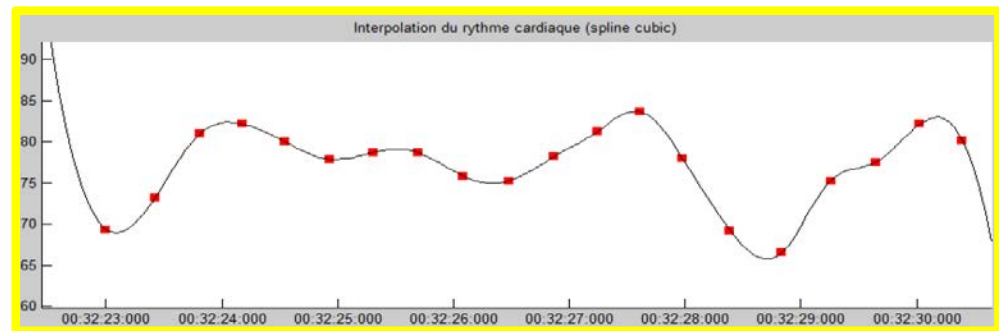
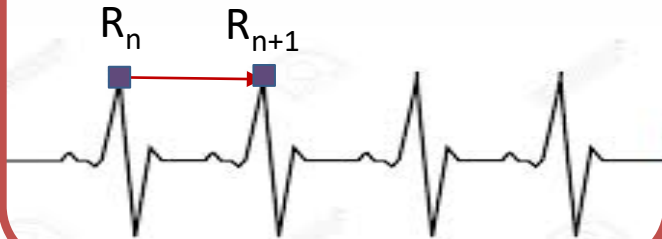
## HR Calculation

- $HR_n = \frac{60,000}{IBI_n}$

## HRC Calculation

- $HRC = HR(t) - HR(t_0)$

## Inter Beat Interval

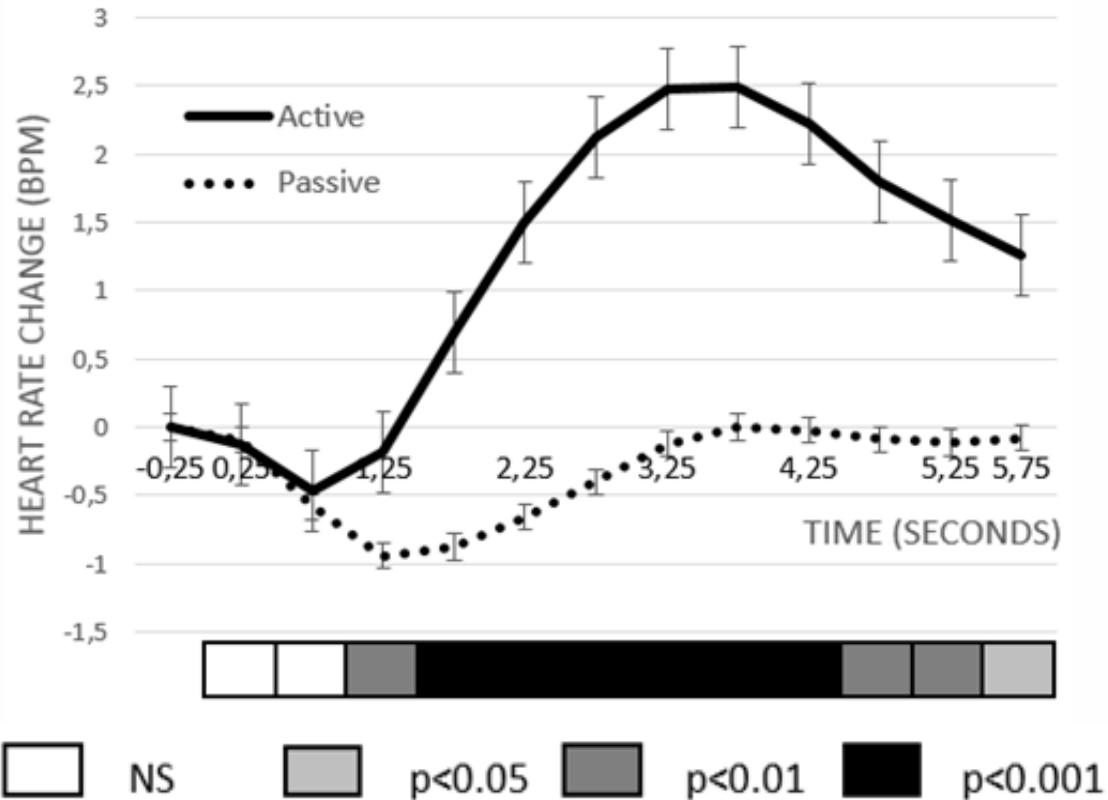


# Results

Data averaged over 1279 events

Comparing each time step with t-tests

High significant difference (<.001) between 1.5 and 4.5 s



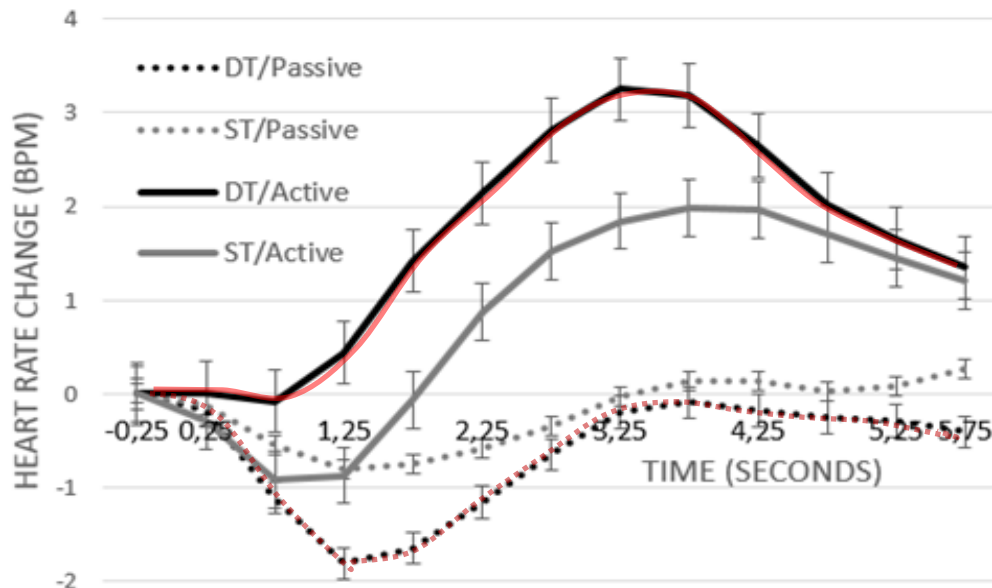


# Results

Data averaged over 1279 events

Comparing each time step with t-tests

Possibility to distinguish Active and Passive conditions



DT/Active vs DT/Passive



NS



p<0.05



p<0.01



p<0.001

ST = Simple Task  
DT = Dual Task

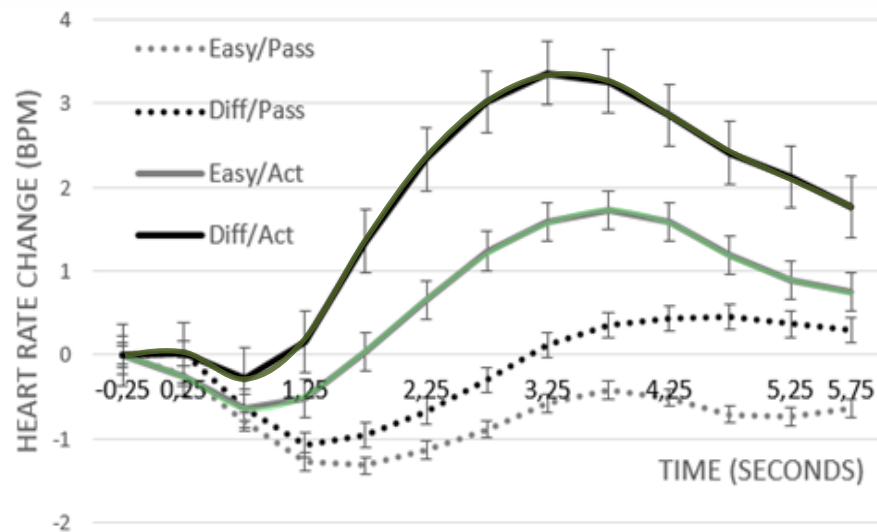
Easy = Beep Task  
Diff = Grid Task

# Results

Data averaged over 1279 events

Comparing each time step with t-tests

- Easy Task : Same Results than other authors.
- Difficult Task : larger amplitude.



Easy/Active vs Difficult/Active



□ NS

■ p < 0.05

■ p < 0.01

■ p < 0.001

ST = Simple Task

DT = Dual Task

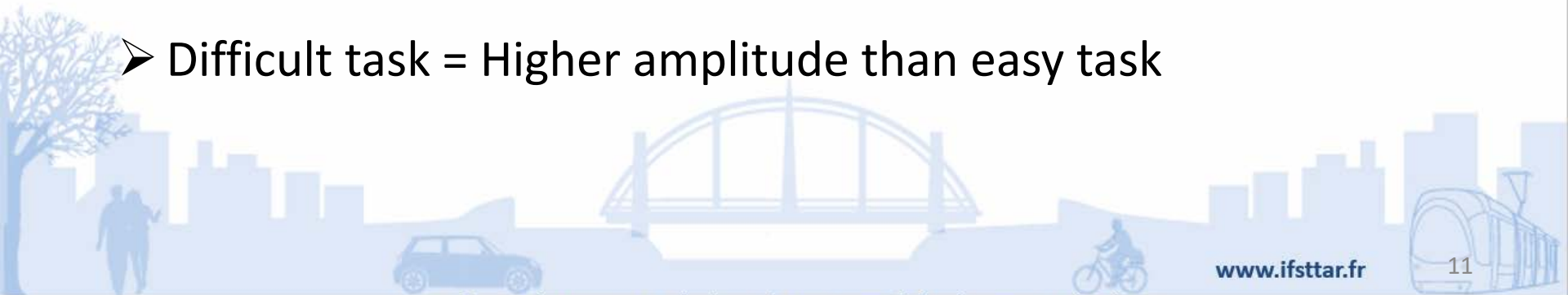
Easy = Beep Task

Diff = Grid Task

# Results

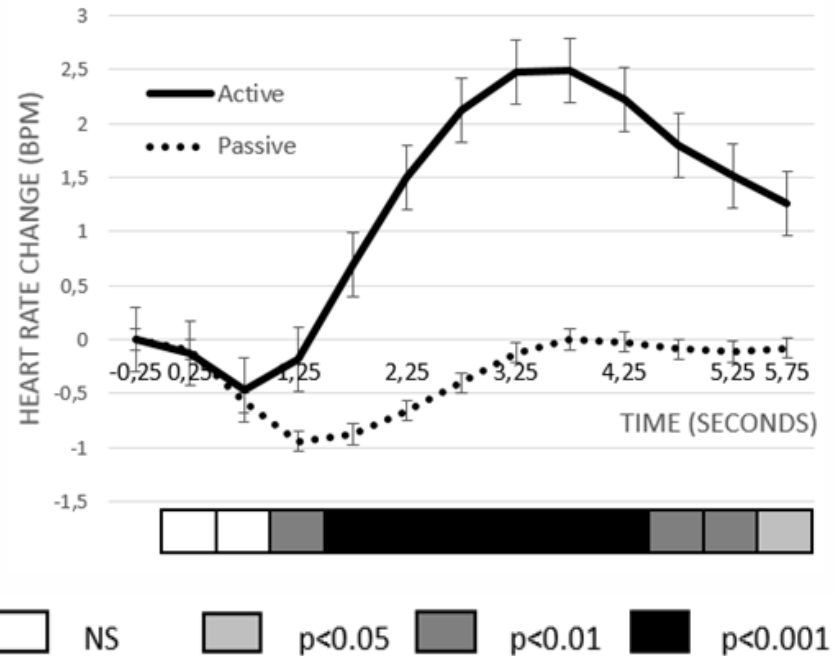
## 3 Important Results:

- Curves obtained match our assumptions for passive and active conditions
- Significant differences with a driving activity for active and passive conditions
- Difficult task = Higher amplitude than easy task



# Discussion

- Expected shape of curves

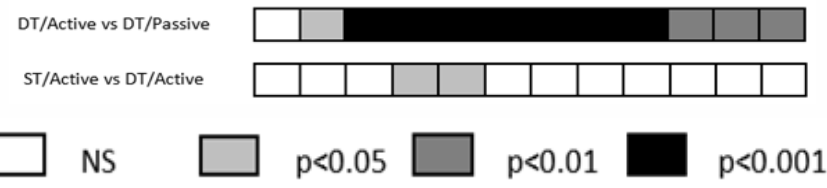
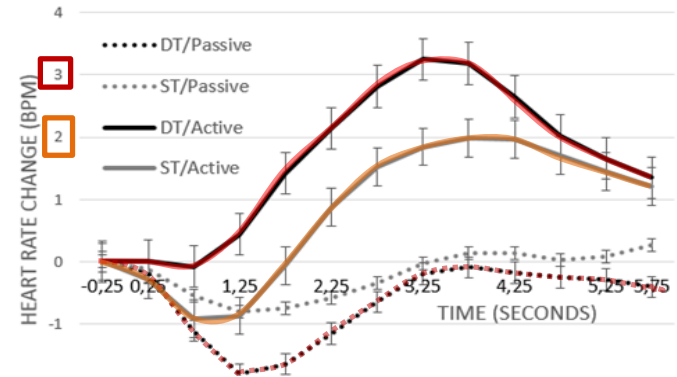


Pepin, G., Jallais, C., Fort, A., Moreau, F., Navarro, J., & Gabaude, C. (2016). *Le travail humain*



# Discussion

- Expected shape of curves
- Cognitive effort indicator suitable for driving
- Is HRC a quantitative indicator of the driver's cognitive effort ?
  - ✓ Effect of the additional driving task

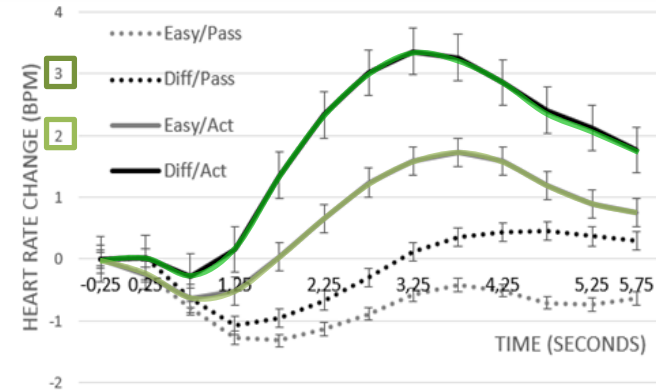


Pepin, G., Jallais, C., Fort, A., Moreau, F., Navarro, J., & Gabaude, C. (2016). *Le travail humain*



# Discussion

- Expected shape of curves
- Cognitive effort indicator suitable for driving
- Is HRC a quantitative indicator of the driver's cognitive effort ?
  - ✓ Effect of the additional driving task
  - ✓ Effect of the task difficulty level



Easy/Active vs Difficult/Active

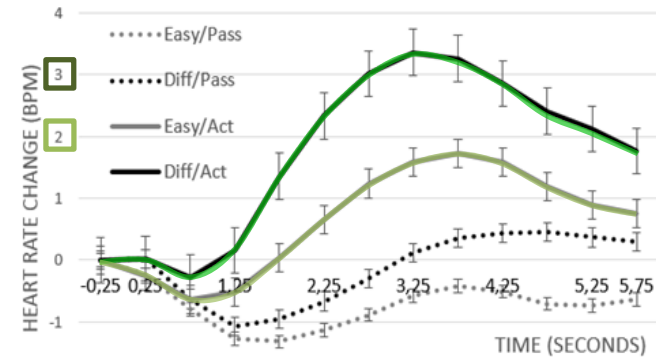


Pepin, G., Jallais, C., Fort, A., Moreau, F., Navarro, J., & Gabaude, C. (2016). *Le travail humain*

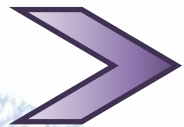
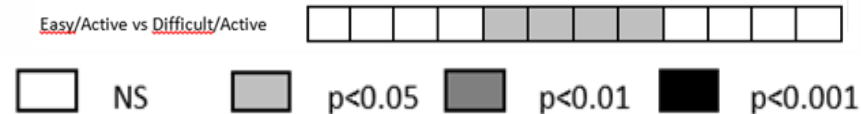


# Discussion

- Expected shape of curves
- Cognitive effort indicator suitable for driving
- Is HRC a quantitative indicator of the driver's cognitive effort ?
  - ✓ Effect of the additional driving task
  - ✓ Effect of the task difficulty level



Easy/Active vs Difficult/Active

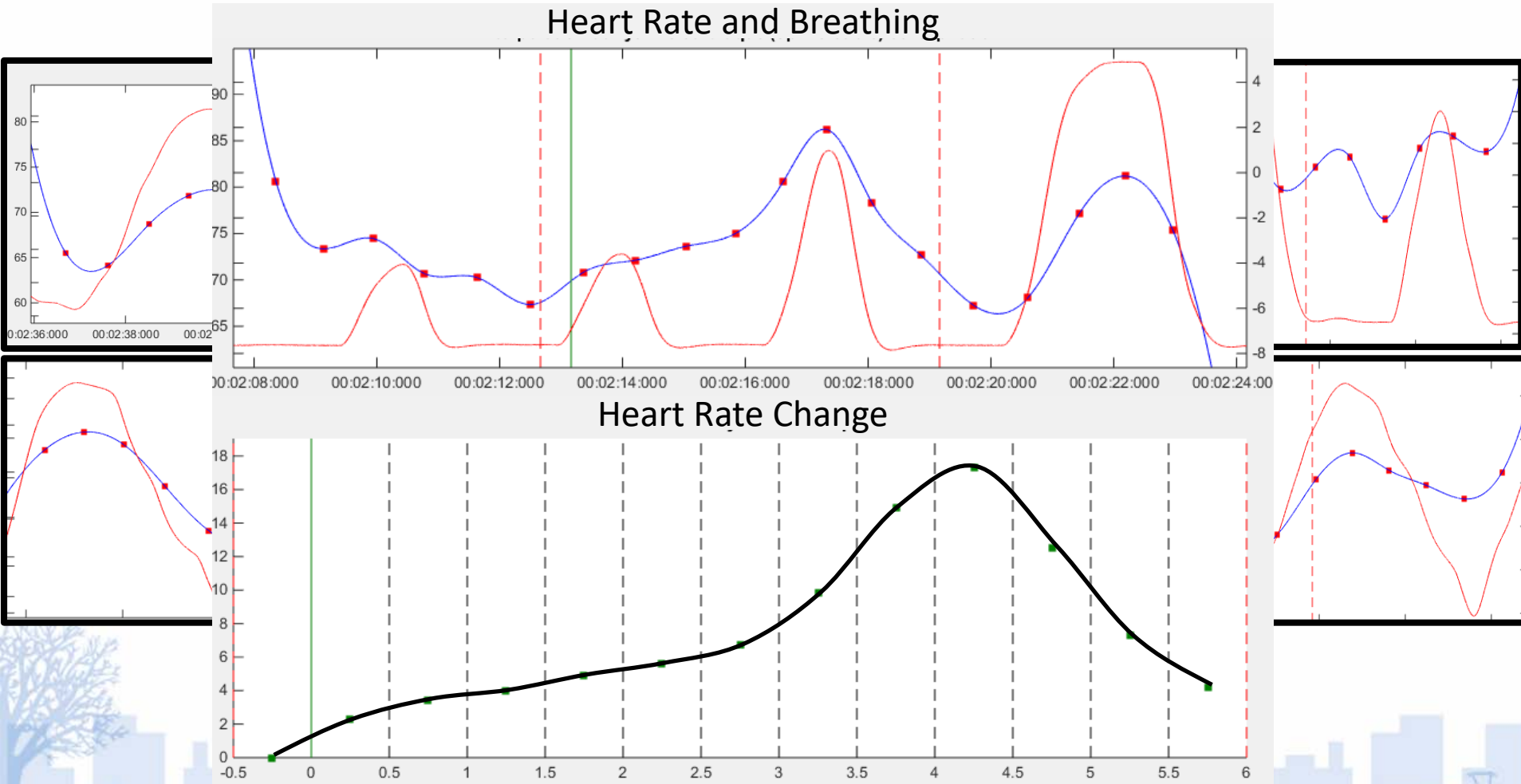


The intensity of HR acceleration seems reflected the « amount » of effort



Data averaged on 150 events by condition: impossibility to detect the cognitive effort in real-time

# Links between HR and Breathing





# Decorrelate ?

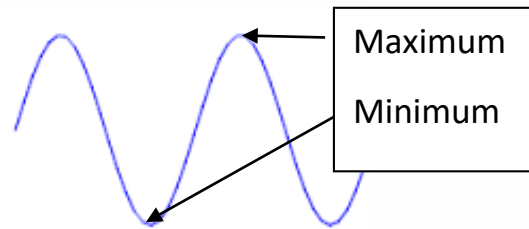
## Using our data for data mining

Empirically quantified the change in HR from respiratory data



Several explanatory variables

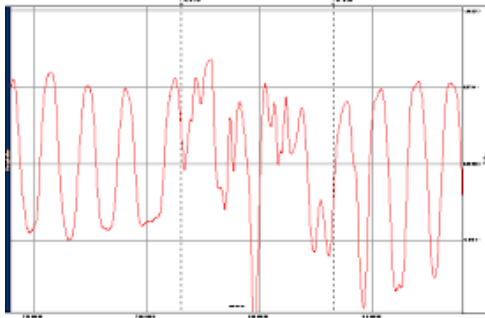
- Amplitude
- Duration
- HR
- Delay
- Time Factor
- ...



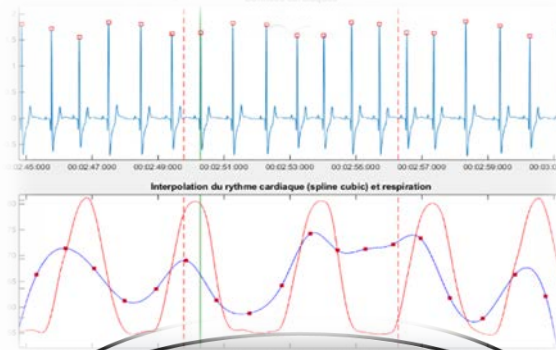
1 variable to be explained : Changes in HR



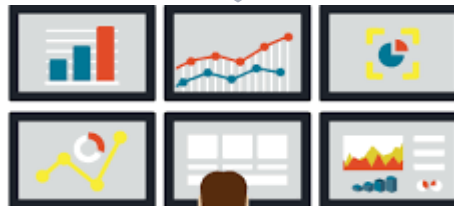
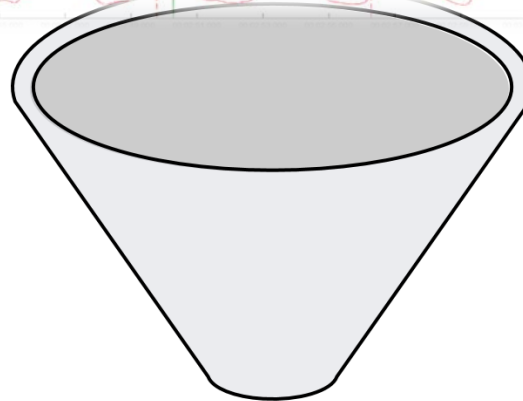
### Respiratory Data



### Cardiac Data



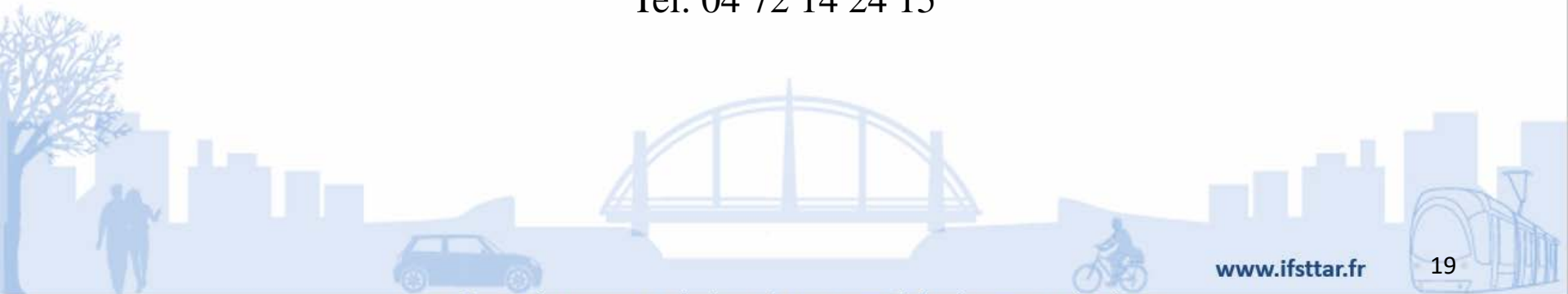
### Driving Data



## MONITORING

# THANK YOU FOR YOUR ATTENTION

Guillaume PEPIN  
IFSTTAR-TS2-LESCOT  
25, Avenue François Mitterrand  
69675 BRON Cedex, France  
Email: [guillaume.pepin\(at\)ifsttar.fr](mailto:guillaume.pepin(at)ifsttar.fr)  
Tel: 04 72 14 24 15



# The Difficult Task

1	2	3	4	5
11	12	13	14	15
21	22	23	24	25
31	32	33	34	35
41	42	43	44	45

“Right”

$$\begin{array}{r} 24 + 14 \\ = 38 \end{array}$$

