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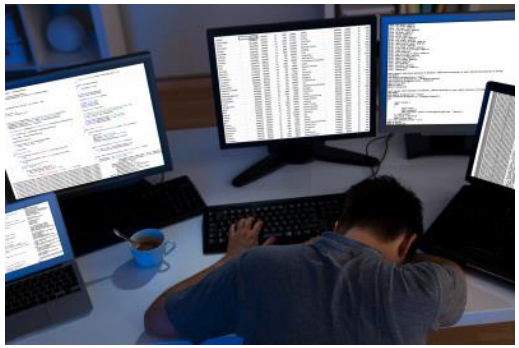
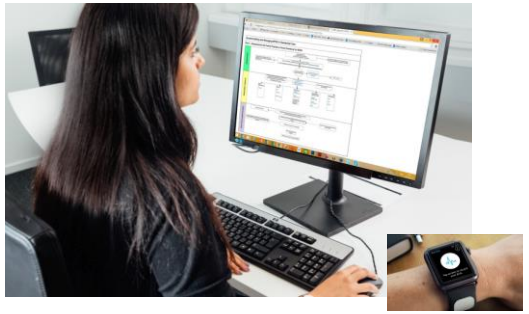
Cognitive and autonomic neural manifestations captured using wearable sensors for reliable software development

Motivation

- 15 to 50 bugs per 1000 lines of code
- $1.1 trillion lost on software bugs, glitches and security failures worldwide in 2016
- Software bugs are a human error
- Current SE complexity metrics do not take into account cognitive load of the programmer

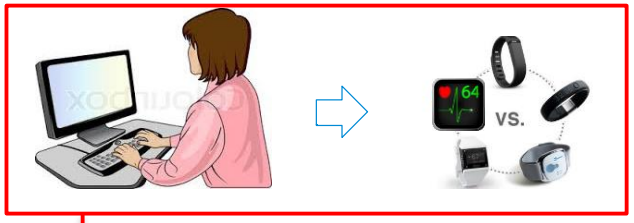


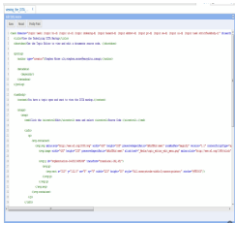
- **Overall objectives**:
  - Development and evaluation of an algorithm for cognitive stress quantification
  - Analysis of the participant's perceived complexity of the mental tasks

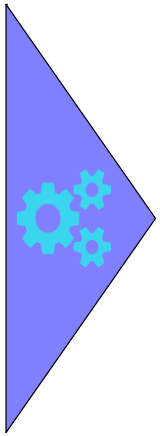


Concept

This work

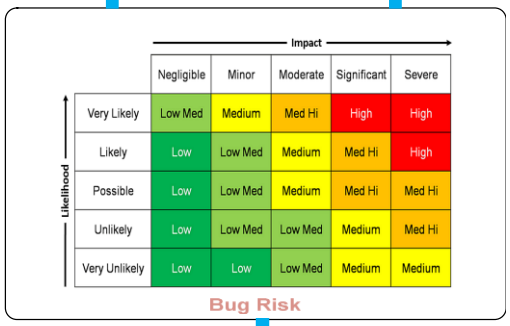






S/W Tests

S/W Defect Density



Realtime Feedback

Feasibility study: assess whether different levels of cognitive stress induced during software inspection can be captured and quantified using autonomic nervous system activity manifestations using wearable sensors (**HRV analysis**)

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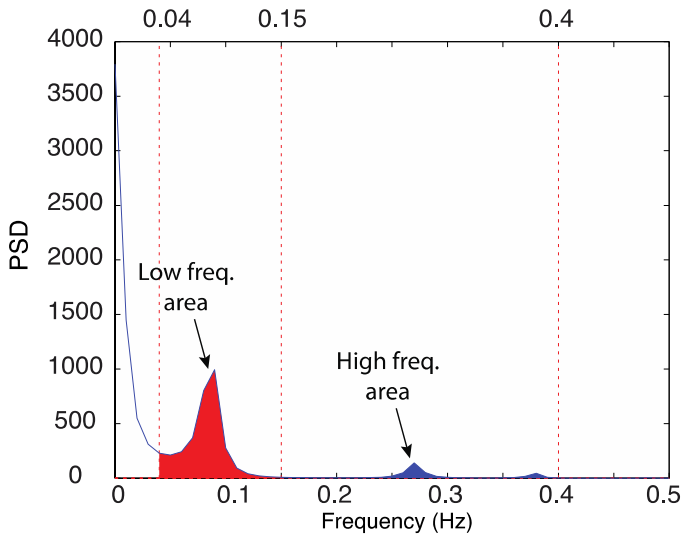
State of the art

- Overload of working memory increases blink latency, pupil size and fixation duration
- Frontal theta EEG activity increases and alpha activity decreases with increasing working memory load
- Heart rate and HRV change with mental task and have the potential to measure stress levels



Data collection study

- Target population:
  - 30 participants
  - Programming proficiency – "intermediate", "advanced" and "expert
- Signals:
  - ECG, EEG, EDA, ICG, PPG, pupillography and eye tracking
- Task:
  - Code understanding (3 levels)

Prog.	Number of lines	Number of parameters	Cyclomatic complexity
C1	13	3	3
C2	42	3	4
C3	49	4	15

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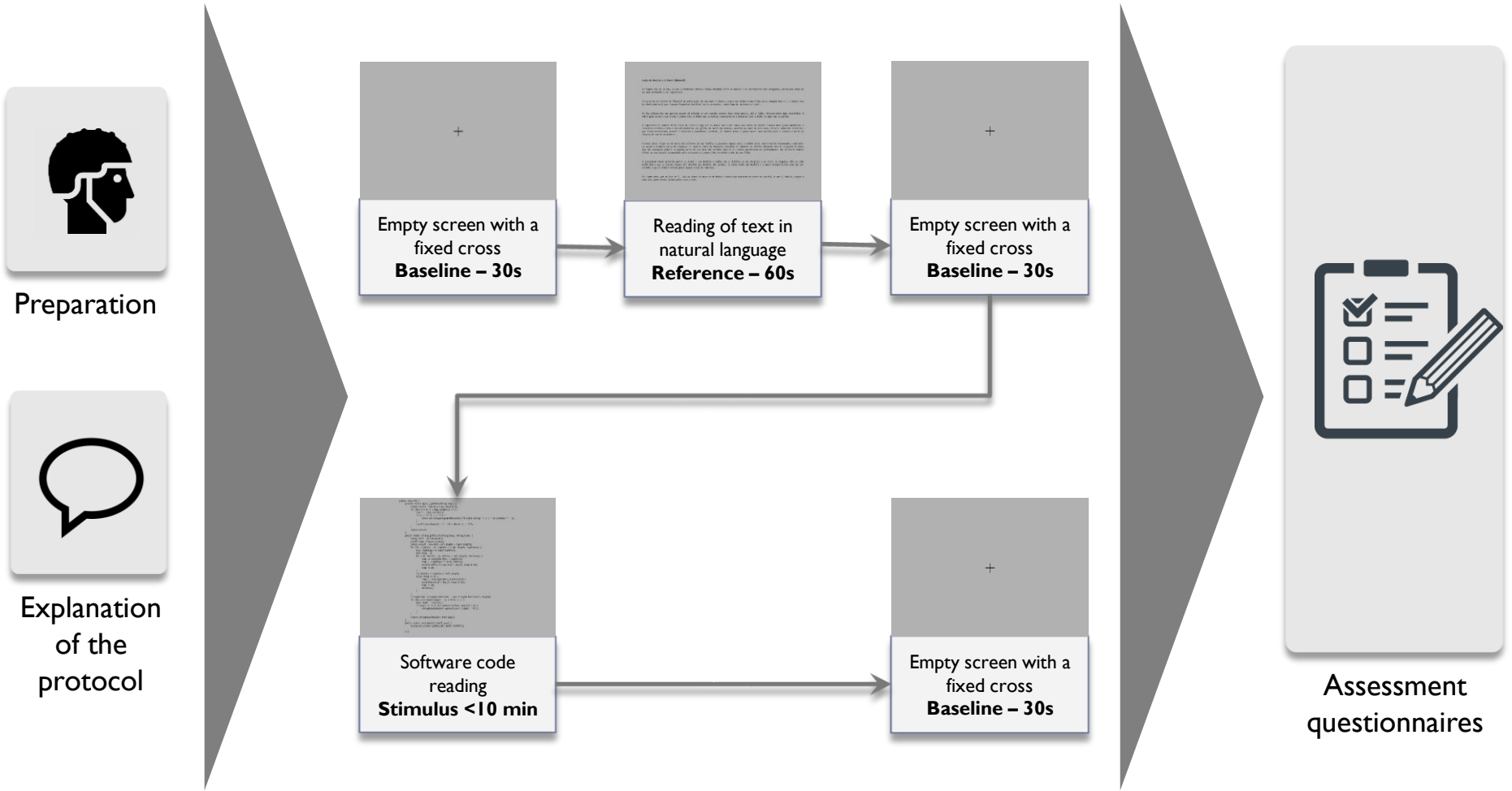
Experimental protocol



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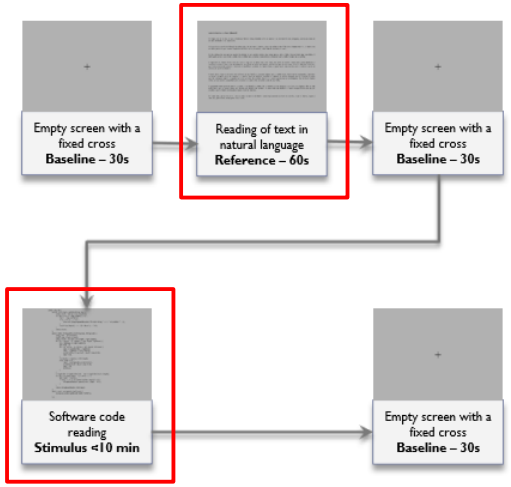
Methods

- Data segmentation
- HRV analysis
  - Feature extraction:
    - 6 time domain features - Mean, SDNN, SDSD, RMSSD, NN50, PNN50
    - 6 frequency domain features – HF, rHF, LF, rLF, TVL, LH
    - Normalization
- Feature selection
  - Normalized mutual information algorithm
- Classification and performance evaluation
  - Support Vector Machine
    - 10-fold cross validation scheme



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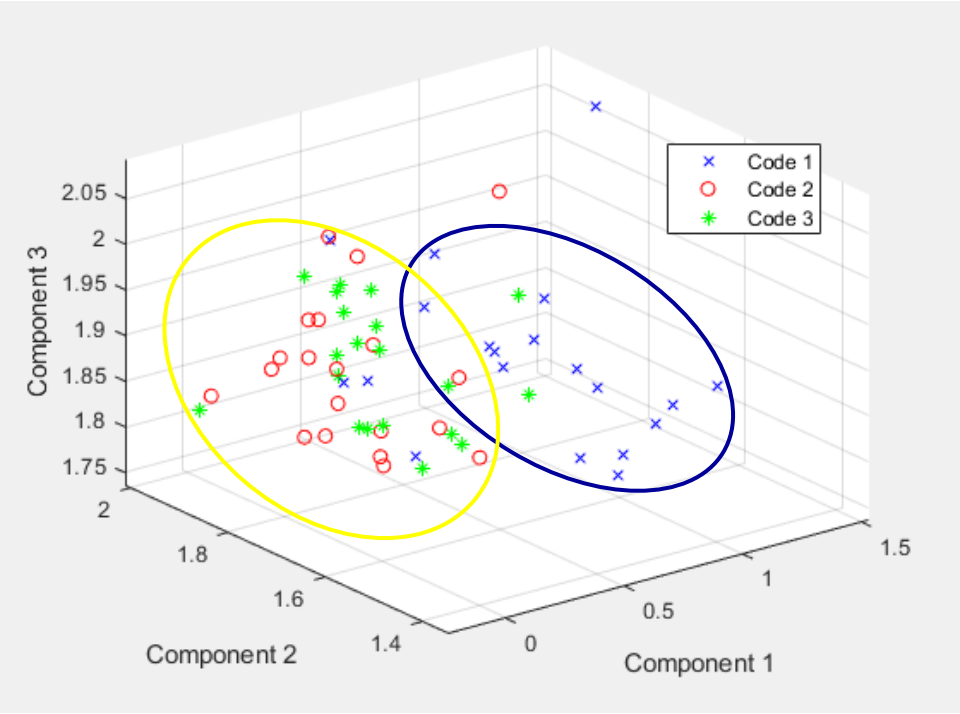
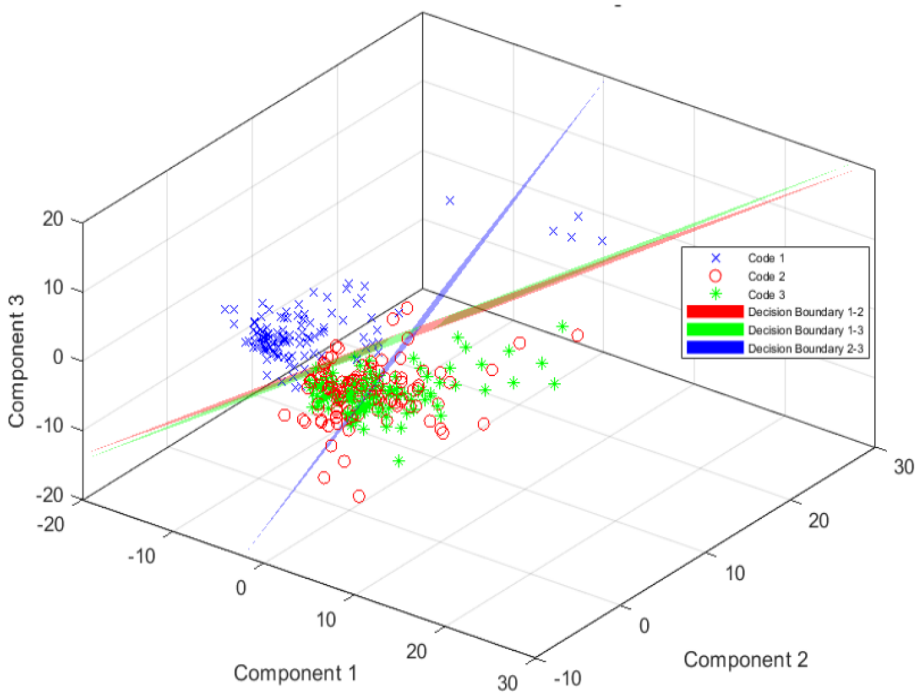
Results

HRV Analysis



EEG Analysis



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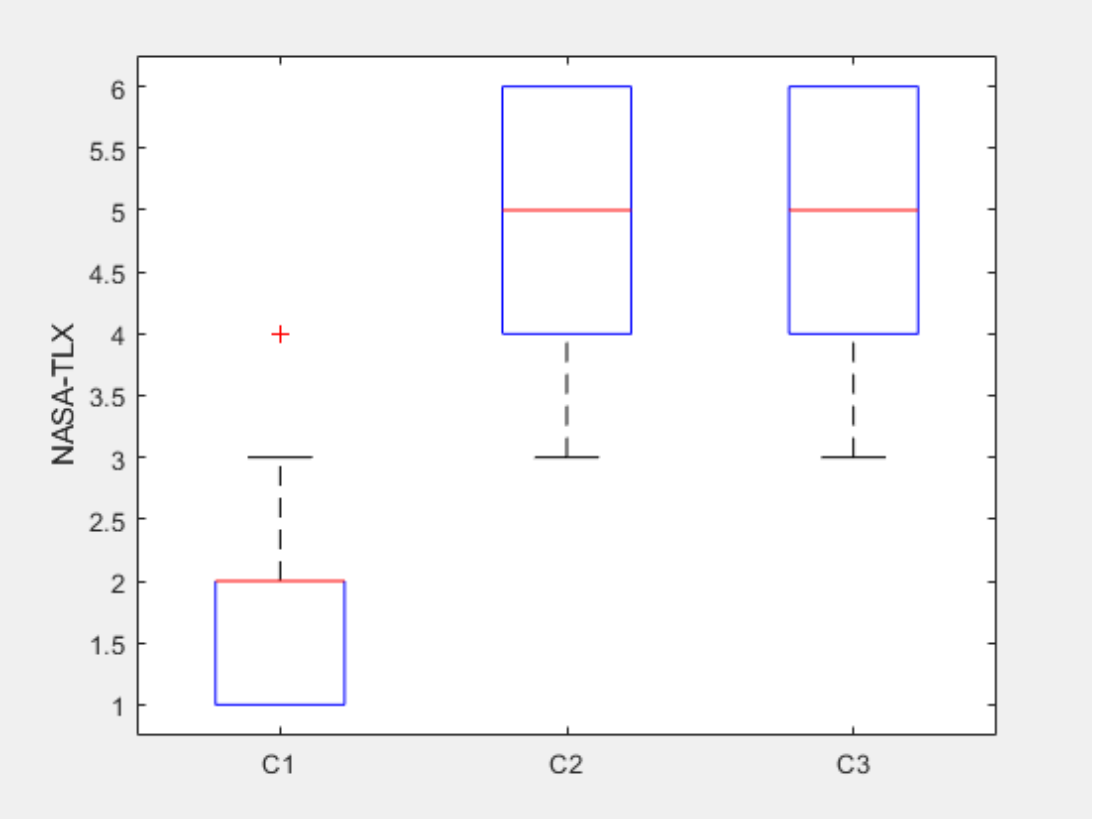
Results



Prog.	Cyclomatic complexity
C1	3
C2	4
C3	15

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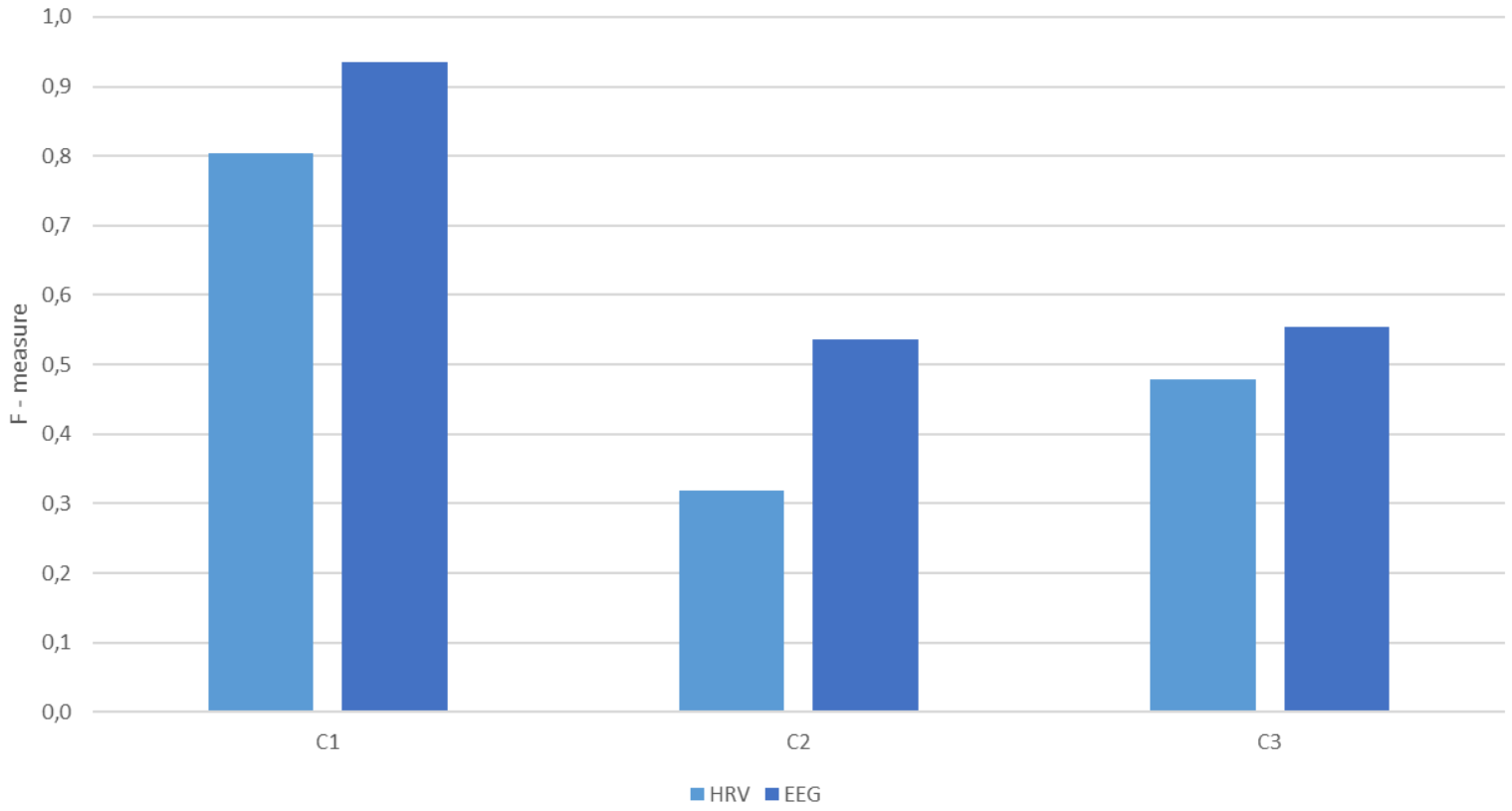
Results



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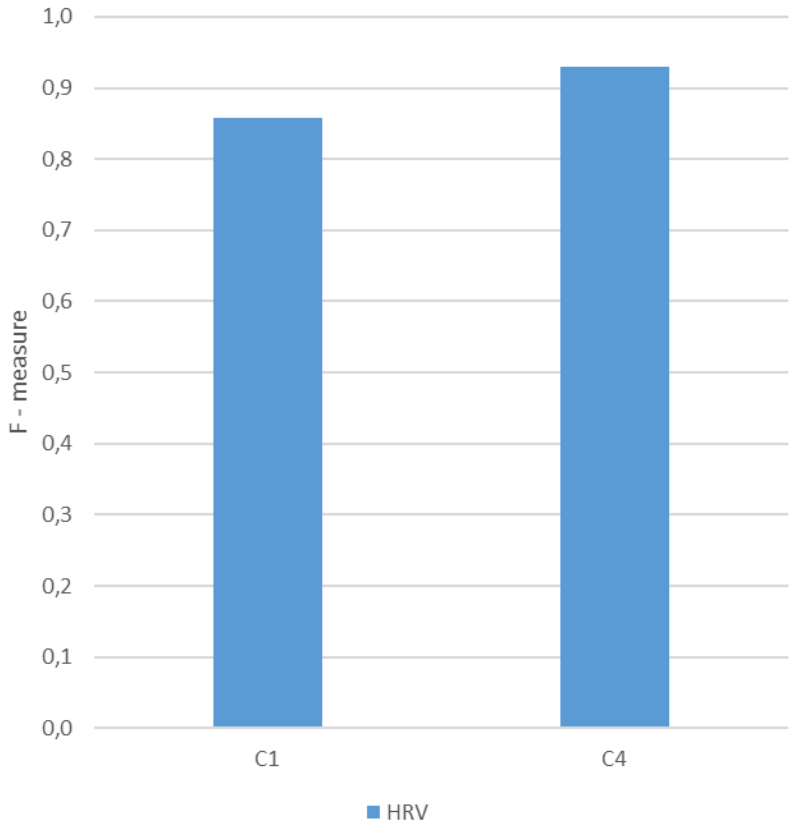
Results



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Main conclusions and future work

- HRV differentiates distinct levels of mental effort during software inspection tasks and is concordant with participant's perceived mental effort
- SE complexity metrics don't portray mental effort
- Mental effort saturates with the increase of the mental task's complexity
- Further research is required in order to assess whether biofeedback can enhance software development paradigms

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Thank you.

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