

# Listening effort: cardiovascular investigation through the point process

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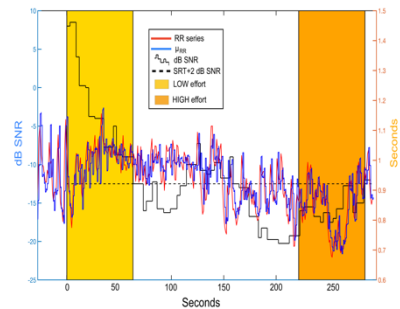
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**INTRODUCTION.** In the context of quantifying listening effort, traditional hearing screening (e.g., pure tone audiometry) or speech recognition thresholds (e.g., speech tests) do not provide significant information about the stress experienced by the subject during listening tasks. Although there have been attempts to quantify memory allocation during acoustics tests, there is no agreement in the literature regarding the role of physiological indices in characterizing different listening effort levels.

**GOAL.** The aim of our study is to ascertain if cardiovascular measurements continuously recorded during a specific task can help in quantifying listening effort.

**METHODS.** In the presented protocol, 21 normal young hearing subjects performed a validated speech-in-noise test, while electrocardiogram (ECG) and blood volume pulse (BVP) were continuously recorded. According to the individual Speech Reception Threshold (SRT), two different effort levels (low and high) were identified during the test. From the ECG and BVP time series, the RR series, the amplitude difference between each systole and diastole and the pulse arrival time were extracted. In addition, the ECG-derived RR series were modelled through a point process framework, yielding instantaneous cardiovascular and autonomic indexes to be considered in our statistical analysis.

**RESULTS.** Overall, the average modelled RR intervals and the pulse arrival time were found to be effective features in distinguishing the two different effort levels ( $p=0.031$  and  $p=0.016$ , respectively). In addition, the amplitude difference between each systole and diastole was able to significantly separate high effort from both low effort and the initial resting period ( $p=4e-4$  and  $p=6e-3$ , respectively).



An example of the measured physiological response during the test is reported for one subject. RR series and the modelled RR ( $\mu$ RR) series are reported in red and blue, respectively. The dark staircase represents the Decibel signal-to-noise ratio (dB SNR) outgoing during the test. The dark dotted line represents the threshold of the subject.