# Abstract

The World Health Organisation defines health as a state of complete physical, social, and mental well-being, a condition that can be threatened by stress. Scientific evidence shows that chronic stress, i.e., a prolonged state of psychological and physiological strain caused by continuous exposure to stressful events, not only contributes to the onset of diseases, but also promotes unhealthy behaviours that increase the risk of chronic conditions. Cardiovascular diseases, cancer, stroke, and respiratory disorders are a few examples linked to chronic stress, which in severe cases can lead to death. The above justifies the growing research interest in strategies aimed at mitigating the harmful effects of stress. Also, given the high variability in how individuals respond to stressors, adaptive and personalised approaches for stress detection and mitigation are necessary.

This manuscript, which is structured in five Chapters, addresses the needs described above through wearable devices, whose widespread adoption makes them a crucial tool for enabling real-world data collection in a non-intrusive, accessible, and cost-effective manner. Despite the significant impact of chronic stress, this work is more focused on acute stress, which arises in the short term when facing a challenging situation. This choice is motivated primarily by the possibility of recreating acute stress in controlled laboratory settings, thereby facilitating investigations.

The first Chapter investigates the challenges researchers may encounter when inducing acute mental stress in controlled conditions and provides guidelines for experimental protocol implementations. Both psychological and technical factors are considered to minimise bias in future data collection and maximise the likelihood of eliciting a stress response in the participants.

The second Chapter introduces a wearable device developed by H-Cube srl: a smart garment meant for collecting the electrocardiogram (ECG), surface body temperature, and chest movements of the user. Particular attention is given to the

ECG, for which a novel denoising algorithm, meant to mitigate the effect of the electromyogram (EMG), is introduced in the third Chapter. The method combines the stationary wavelet transform (SWT) with template matching, and it was tested on ECG corrupted by simulated and experimental EMGs. Compared to traditional thresholding techniques, commonly applied to SWT-transformed data to reduce noise, the proposed approach shows statistically superior performance in signal denoising and statistically higher sensitivity and precision of R-peaks estimation than traditional thresholding methods.

The fourth Chapter introduces a novel auditory stimulation method, called adaptive binaural beats (ABB), designed to mitigate the effects of acute stress elicited by a mental arithmetic task (MAT). More specifically, the stimulation frequency of the binaural beats was constantly adapted in the theta range (4.0 - 8.0 Hz) according to the stress state of the user, which was estimated in real-time through the ECG. A pilot study was conducted on 13 healthy participants, and ABB was compared against the constant binaural beats (CBB) stimulation, representing the standard approach for delivering this auditory stimulus. Results show that ABB leads to a statistically lower heart rate than CBB stimulation while performing MAT. Furthermore, results indicate an increase in parasympathetic activity when adopting ABB stimulation.

Finally, the last Chapter discusses future perspectives for the denoising algorithm presented in this manuscript, as well as for stress elicitation (e.g., through virtual reality) and stress mitigation (e.g., via the integration of multimodal and adaptive stimulation strategies), outlining possible directions for future research.