Detecting Individual Responses to Acute and Progressive Moderate Stress by the use of Heart Rate Variability

Sarah Folio*[1,2], Stéphanie Dabic[2], Laora Kerautret[2], Laurent Arsac[1], and Véronique Deschodt-Arsac[1]

[1]Laboratoire IMS, équipe
$\mathrm{PMH}_{D}ySCo--CNRS:UMR5218, Universitédebordeaux(Bordeaux, France)--France$
[2]Valeo Brain Division – valeo – France

Résumé

Introduction

While numerous studies have examined psychophysiological responses to marked stressors, either in acute or chronic conditions, little is known about more current situations where one is exposed to low-intensity stressors-despite obvious relevance in real-world settings such as learning, performance, or daily life.

Heart rate variability (HRV), derived from the analysis of RR interval time series, offers valuable insights into autonomic nervous system dynamics by reflecting shifts in parasympathetic (vagal) and sympathetic activity-both of which govern short-term cardiovascular regulation. As such, HRV markers are widely used to describe responses to a marked stress (Kim et al., 2018), generally reporting increase in sympathetic modulations reflected in Low-Frequency (LF) of the HRV signal, and a drop in HRV entropy, a marker of signal irregularity (complexity) in most people (Dimitriev et al., 2016).

The present study aims to analyze the effects of moderate stressors, an acute or progressive change in auditory stimulation on HRV markers. We hypothesize that such mild stressors may induce subtle autonomic modulations, potentially absent in some people, highlighting the need for individualized approaches (clustering).

Methods

Seventeen healthy students (13 males, 4 females; 19.18 ± 1.55 years) gave their informed consent to participate in the study. They were equipped with ECG electrodes for cardiac recording.

Cardiac interbeat intervals were obtained as R-to-R peaks interval durations (RR), inspected for artifacts and analyzed as RR time series also called Heart Rate Variability (HRV).

Each participant underwent two randomized 10min sessions while seated, wearing headphones and viewing a documentary. Each 10min session was divided into three phases:

*Intervenant

_˜5min baseline (PRE), followed by either an acute stressor (15s auditory stress, *Acute Stress,* Acute) or a progressive stressor (1min of gradually increasing auditory stress, *Progressive Stress*, Prog), and _˜5min post-stressor recovery period (POST).

HRV markers were obtained for PRE and POST phases. The root mean square of successive differences (RMSSD) served as an index of parasympathetic modulation. The HRV signal was decomposed using Wavelet Packet Transform (WPT) to obtain LF and HF power as markers of sympathetic and parasympathetic modulation. The notion of irregularity (complexity) in HRV was captured computing Refined Composite Multiscale Entropy (RCMSE).

HRV markers for PRE and POST conditions were compared using a Wilcoxon test.

The response to stress-acute or progressive-was characterized by calculating (POST-PRE)/PRE changes in HRV markers. These quantitative variables were introduced in a Principal Component Analysis (PCA) followed by hierarchical clustering of individuals using a Hierarchical Clustering on Principal Components (HCPC).

Results & Discussion

In condition ACUTE, no significant difference was observed between POST and PRE HRV markers. In contrast, in PROG, HRV entropy was higher in POST condition ($p = 0.005$).

The large inter-individual variability observed in each HRV marker was illustrated by two clusters obtained with HCPC in ACUTE: a marked vs. low change in LF distinguished Cluster 1 from Cluster 2. Our interpretative hypothesis is the existence of Responders and Non Responders to the moderate acute auditory stressor, which resembles what has been observed in the literature when using marked stressors. In our specific conditions that used a moderate stress, Responders were only 4 out of 17 participants, which indicates that LF is a reliable marker to detect sensitive people.

In condition PROG, three clusters were identified, where a number of Non-Responders were also identified in one cluster. More interestingly, among Responders to the progressive auditory stress, the clustering approach distinguished Responders characterized by high LF, a response similar to that observed in ACUTE, and Responders characterized by high entropy and total autonomic power, which is interpreted by an enhanced heart-brain interplay (Blons et al. 2019; (Thayer & Lane, 2009).

Conclusion

Here we show that HRV markers are sensitive enough to report on the effects of a moderate auditory stressor in young, healthy adults. Applying the stressor in acute or progressive conditions generates distinctive autonomic responses with high interindividual manifestations. A progressive stressor may induce rather deleterious (high LF) or beneficial (heightened entropy) effects, depending on individuals.

References

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