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Heart rate variability is associated with psychosocial stress in distinct social domains

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ABSTRACT

Objective: Psychosocial stress is associated with substantial morbidity and mortality. Accordingly, there is a growing interest in biomarkers that indicate whether individuals show adaptive (i.e., stress-buffering and health-promoting) or maladaptive (i.e., stress-escalating and health-impairing) stress reactions in social contexts. As heart rate variability (HRV) has been suggested to be a biomarker of adaptive behavior during social encounters, it may be possible that inter-individual differences in HRV are associated with inter-individual differences regarding stress in distinct social domains.
Methods: To test this hypothesis, resting state HRV and psychosocial stress was assessed in 83 healthy community-dwelling individuals (age: 18–35 years). HRV was derived from heart rate recordings during spontaneous and instructed breathing to assess the robustness of possible associations between inter-individual differences in HRV and inter-individual differences in psychosocial stress. Psychosocial stress was determined with a self-report questionnaire assessing stress in distinct social domains.
Results: A series of categorical and dimensional analyses revealed an association between inter-individual differences in HRV and inter-individual differences in psychosocial stress: Individuals with high HRV reported less stress in social life, but not in family life, work life or everyday life, than individuals with low HRV.
Conclusions: On basis of these findings, it may be assumed that individuals with high HRV experience less psychosocial stress than individuals with low HRV. Although such an assumption needs to be corroborated by further findings, it seems to be consistent with previous findings showing that individuals with high HRV suffer less from stress and stress-related disorders than individuals with low HRV.

1. Introduction

As social beings, we rarely spend our time in isolation [1]. Most of our time, we are surrounded by other individuals, making it almost impossible to avoid social interactions. We have to interact with individuals that are well-known to us, like partners and friends, but also with individuals that are less known to us, like colleagues and customers. These interactions are marked by different types of challenges and opportunities, implying that we may experience different levels of stress throughout these interactions [2]. Although interacting with other individuals may help us to cope with stressful experiences [e.g., [3,4]], these interactions may also be stressful for us [e.g., [5,6]]. In particular negative interactions, that is, interactions with individuals that behave unexpectedly or unpredictably in potentially threatening contexts [7], are accompanied by a plethora of stress reactions [8,9]. On the subjective level, we may experience a change in emotion and cognition, like, for example, an increase in negative feelings [e.g., [10,11]] or an increase in attention for negative information [e.g., [12,13]]. On the behavioral level, we may show a change in behavior, like, for example, an increase in agnostic behavior in terms of insults and attacks [e.g., [14,15]] or an increase in affiliative behavior in terms of concessions and compromises [e.g., [16,17]]. On the neurobiological level, we may experience a change in autonomic and endocrine reactivity, like, for example, an increase in cardiovascular activity [e.g., [18,19]] or an increase in glucocorticoid and catecholamine activity [e.g., [20,21]]. Although these stress reactions may help us to cope with other individuals in potentially threatening contexts, they may also put us at risk for several diseases [22]. As psychosocial stress is associated with substantial morbidity and mortality [23], there is a growing interest in biomarkers that indicate whether we show adaptive (i.e.,

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stress-buffering and health-promoting) or maladaptive (i.e., stress-escalating and health-impairing) stress reactions in social contexts.

In recent years, heart rate variability (HRV), an index of consecutive changes in heart beat [24], has been considered as a promising biomarker for adaptive behavior during social encounters [25,26]. Our subjective, behavioral and neurobiological responses to other individuals are orchestrated by a network of prefrontal and (para-)limbic brain regions [25–27]. Activity and connectivity changes in this network of brain regions are associated with changes in HRV [e.g., [28,29,30]], indicating that inter-individual differences in HRV may reflect inter-individual differences regarding the interplay between prefrontal and (para-)limbic brain regions during the regulation of social behavior. HRV measures may, thus, enable us to assess whether an individual shows adaptive or maladaptive behavior during social interactions. Adaptive behavior is generally reflected by a less efficient interplay of prefrontal and (para-)limbic brain regions that is associated with an increase in HRV, whereas maladaptive behavior is generally reflected by a less efficient interplay of prefrontal and (para-)limbic brain regions that is associated with a decrease in HRV. Individuals with high HRV are more sensitive to the emotional states of others [e.g., [31,32–34]] and are more skilled to regulate their emotional and behavioral responses towards others [e.g., [35–37]] than individuals with low HRV. Accordingly, individuals with high HRV are more likely to initiate and maintain positive social interactions than individuals with low HRV [e.g., [38,39]]. It may, thus, be possible that individuals with high HRV also experience less stress during social encounters than individuals with low HRV. This may explain why individuals with high HRV are less likely to suffer from stress-related diseases, like, for example, cardiovascular diseases [e.g., [40,41]] or major depressive disorder [e.g., [42,43]], than individuals with low HRV.

Although inter-individual differences in HRV have been suggested to reflect inter-individual differences in the experience and regulation of stress in social contexts [25–27], this has hardly been investigated yet. We, thus, further investigated whether inter-individual differences in HRV would be associated with inter-individual differences in psychosocial stress. Inter-individual differences in HRV were determined on basis of short-term recordings of heart rate (HR) under resting state conditions, whereas inter-individual differences in psychosocial stress were determined on basis of a self-report questionnaire. The self-report questionnaire assessed inter-individual differences regarding stress experiences in distinct social domains. Some domains were characterized by interactions with familiar individuals, such as family life or social life, and other domains were characterized by interactions with unfamiliar individuals, such as work or everyday life. As our stress levels are more likely to change during interactions with familiar than unfamiliar individuals [e.g., [44,45–51]], we hypothesized that the association between inter-individual differences in HRV and inter-individual differences in psychosocial stress would be more pronounced during encounters with familiar than unfamiliar individuals. Individuals with high HRV were, thus, expected to report less stress in family and social life than individuals with low HRV. Reports of stress in everyday life and work life, on the contrary, were not expected to differ between individuals with high and low HRV. To determine the robustness of the hypothesized association between inter-individual differences in HRV and inter-individual differences in psychosocial stress, we performed a series of categorical and dimensional analyses on basis of HR recordings that were obtained during spontaneous and instructed breathing.

2. Method

2.1. Participants

We performed an a priori power analysis to determine the number of participants that we needed to detect meaningful associations between inter-individual differences in HRV and inter-individual differences in psychosocial stress. G*Power [52] indicated that we had to recruit 82–90 participants in order to have sufficient power ($1 - \beta = 0.80$, $\alpha = 0.05$) to detect medium-sized effects in our dimensional ($r = 0.30$) and categorical ($f = 0.30$) analyses. Using local advertisement, 84 community-dwelling participants were recruited from the urban area of Rostock between June and September 2016. As a consequence, our dimensional analyses were appropriately powered ($1 - \beta = 0.80$) and our categorical analyses were slightly under-powered ($1 - \beta = 0.78$). In order to be included in the study, participants had to be aged between 18 and 35 years and to be native German speakers. Participants with mental disorders and participants who were in psychotherapeutic treatment were excluded from the study. Inclusion and exclusion of participants was determined on basis of a self-report questionnaire assessing sociodemographic (age, sex), anthropometric (height, weight) and psychopathological (mental health) participant characteristics. One participant did not provide valid data due to equipment malfunction and was subsequently excluded from the analyses. We, thus, considered 83 participants that provided valid and complete data in our analyses (see Table 1).

Table 1
Participant characteristics.

	M (SD)	95% CI
Age	26.35 (4.09)	[25.46, 27.24]
Sex (m/f)	41/42	
Heart rate variability during recordings with spontaneous breathing (HRV-SB)		
RMSSD-SB (ms)	44.00 (28.20)	[37.85, 50.16]
Log-RMSSD-SB (ms)	1.57 (0.25)	[1.52, 1.63]
Heart rate variability during recordings with instructed breathing (HRV-IB)		
RMSSD-IB (ms)	35.20 (24.36)	[29.88, 40.52]
Log-RMSSD-IB (ms)	1.47 (0.26)	[1.41, 1.53]
Stress (KFB)		
Social life	1.91 (0.89)	[1.72, 2.11]
Family life	1.52 (0.76)	[1.35, 1.68]
Work life	1.11 (0.98)	[0.89, 1.32]
Everyday life	0.52 (0.68)	[0.37, 0.67]

Note. 95% CI = 95% confidence interval, m = male, f = female, HRV = heart rate variability, SB = spontaneous breathing, IB = instructed breathing, RMSSD = root mean square of successive differences between consecutive heart beats, Log-RMSSD = log transformed root mean square of successive differences between consecutive heart beats, KFB = modified version of the Hassles and Uplifts Scale [55,61].

All participants provided written-informed consent before taking part in the study and were fully debriefed after completion of the study. The study was approved by the local ethics committee and carried out in accordance with the Declaration of Helsinki.

2.2. Procedure

Participants' visits to the laboratory were scheduled between 8 a.m. and 8 p.m. After arrival at the laboratory, participants were asked to use the bathroom to control for the effects of bladder filling and gastric distension on HRV [53]. Participants were then seated in a comfortable chair and prepared for the HR recording. To control for the effects of breathing patterns on HRV [53], HRV was recorded during spontaneous breathing (5 min) as well as during instructed breathing (5 min). Whereas participants breathed at a self-paced rate during spontaneous breathing, participants breathed at a metronome-paced rate (0.25 Hz) during instructed breathing [54]. HR recording during instructed breathing was always preceded by HR recording during spontaneous breathing to avoid carry-over effects from instructed to spontaneous breathing [54]. After the HR recording, participants completed an online self-report questionnaire that assessed psychosocial stress in different social domains [Kurzer Fragebogen zur Erfassung von