Int. J. Behav. Med. (2009) 16:236–240
DOI 10.1007/s12529-009-9034-8

Cardiac Stress Reactivity and Recovery of Novelty Seekers

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Published online: 31 March 2009

Abstract
Background Novelty seeking temperament has been associated with higher coronary heart disease risk factors, but the mechanism behind the association is open. Cardiac stress response is a potential candidate.
Purpose Cardiac stress reactivity and recovery was studied in 29 healthy subjects (aged 22–37 years) scoring extremely high (n=16) or extremely low (n=13) on temperamental dimension of novelty seeking.
Method Heart rate, respiratory sinus arrhythmia, and pre-ejection period were measured during challenging tasks. Differences in cardiac reactivity and recovery between the novelty seeking groups were examined with repeated-measures and univariate analyses.
Results The main finding was that stress reactivity did not differ between high and low novelty seeking groups, but high novelty seekers tended to show faster recovery, which is likely to be parasympathetically mediated.
Conclusion The findings suggest that high novelty seekers may be more stress resilient because they might have faster cardiac recovery after stress. Cardiac stress reactivity seems not to be among the explaining factors for the association between novelty seeking and coronary heart disease risk factors.

Keywords Temperament · Novelty seeking · Cardiac reactivity · Cardiac recovery · Autonomic nervous system

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Introduction

Temperament refers to biologically rooted individual differences in behavioral style and reactivity [1]. Temperament is based on individual differences in reactivity and brain metabolism [2], and it plays a central role in stress vulnerability [3]. For instance, temperament is considered to be a moderator of what one indentifies as a stressor, a state of stress, efforts to cope with stress, and the psychophysiological costs of the states of stress [4].

Novelty seeking is one of the four temperament dimensions of Cloninger's temperament model. It is characterized by an active avoidance of monotony and a tendency for frequent exploratory activity and intense excitement in response to novel and unexpected stimuli [5]. Novelty seeking has been often associated with higher behavioral coronary heart disease risk factors, such as smoking and alcohol consumption, and also with some somatic risks, e.g., triglycerides and obesity indicators [6, 7]. Furthermore, novelty seeking has been associated with higher preclinical atherosclerosis as indicated by intima–media thickness [8]. However, the mechanism behind these associations is open. Cardiac stress reactivity and recovery could be possible mechanisms. To our knowledge, there are no previous studies on the association between novelty seeking and stress-related cardiac reactivity and recovery.

The current study was taken with a purpose to examine whether novelty seeking is associated with cardiac reactions to a laboratory challenge. We asked whether stress-induced cardiac reactivity and recovery of high novelty seekers differs from that of persons with low levels of novelty seeking. We examined the extreme ends of high and low novelty seeking, which greatly increases the power of the analyses.

Method

Subjects

The subjects were 38 healthy men and women (aged 22–37 years) participating in the ongoing population-based study of "Cardiovascular Risk in Young Finns" [9, 10]. In this study, a sample of 3,596 randomly selected healthy Finnish children and adolescents has been monitored since 1980. The design of the study and the selection of the sample have been described previously [9]. During the fifth follow-up of the Young Finns study in 1997, the subjects completed the Temperament and Character Inventory (TCI) [5]. Complete data were obtained from 2,109 subjects (844 men, 1,265 women). From this population, 20 men and 18 women were selected to participate in a psychophysiological study on the basis of their novelty seeking scores. These subjects fell into the highest 6% (n=20) or lowest 5% (n=18) of the novelty seeking scale. In the current study, participants were required to have full data on all study variables. Therefore, the final sample consisted of 29 participants (13 low novelty seekers, 16 high novelty seekers) except for pre-ejection period (PEP) recovery after reaction time task and PEP recovery in repeated measures, which were conducted on 28 participants (one less high novelty seeker than in other analyses).

Procedure

The experiment was conducted in a sound-attenuated room with a computer for stimulus presentation and a video system for communication and monitoring. The experiment consisted of five task and six resting periods. The tasks were: (a) emotion-evoking picture viewing, (b) acoustic startle stimuli, (c) mental arithmetic task, (d) reaction time task, and (e) public-speaking task. In the present study, only mental arithmetic, reaction time task, and speech task were used, however. These three tasks were chosen because they are likely to induce tonic and systematic changes in autonomic cardiac activity. The experiment started and ended with a resting period of 10 min (baseline and last rest). The resting periods between the tasks were 8, 5, 8, and 8 min (in this order). In total, the experiment lasted for about 180 min, and the experimental situation began at the same time of day (9:00 A.M.) for all subjects.

Measures

Mental Arithmetic Task The subjects were asked to perform six 1-min serial subtraction problems, adjusted for individual differences in mathematical skills, continuously for 6 min. Task difficulty was contingent on the subject's performance during the preceding minute.

Choice-Deadline Reaction Time Task Repeated choice-deadline trials were presented to the subject in three increasingly difficult blocks (ten trials per block). Each trial consisted of (a) a fore-period varying randomly between 2.5 and 4 s; (b) a stimulus period, during which a 1,000- or 2,000-Hz tone was presented; (c) a response period, during which the subject had to push one of two buttons (green button for 1,000 Hz, or red button for 2,000 Hz) with an noxious 105 dB white noise of 0.5 s duration being presented if the response was incorrect or too slow; and (d) a feedback period.

Speech Task The participants were asked to construct and deliver three speeches (a 3-min speech after a 3-min silent preparation period), each on a different subject. All tasks and task conditions are described in more detail elsewhere [11, 12].

Novelty Seeking The novelty seeking temperament of the subjects was measured by Cloninger's TCI, a 240-item questionnaire [5]. The TCI assesses four temperament dimensions and three character dimensions as defined by Cloninger's [5] model of temperament. In the present study, only the novelty seeking scale, comprised of 40 items, was used.

Data Analysis

During the psychophysiological experiment, electrocardiogram (ECG) was assessed with a Minnesota Impedance Cardiograph (Model 304B) using the standard tetrapolar band electrode configuration [13]. The ECG and dZ/dt signals were sampled at a rate of 500 Hz, and interbeat intervals were derived from a self-programmed software. The positions of the Q wave in the ECG and the B point in the d*Z*/d*t* signal were detected using self-programmed software (Labview, National Instruments, Austin, TX, USA), which was checked visually and edited for artifacts. The PEP, which reflects the sympathetic myocardial drive (see, e.g., [14]), was calculated as the interval (in milliseconds) between the onset of the ECG Q wave and the onset of left ventricular ejection (B point).

The spectral analyses were performed on 60-s segments of the heart period series, which were detrended prior to spectral analysis by removing series mean and linear trend. The logarithm of the variance within the frequency band associated with respiration (i.e., 0.12–0.40 Hz) was summed to index respiratory sinus arrhythmia (RSA). RSA is mediated predominantly by vagal–cardiac nerve traffic and is considered an index of parasympathetic activity [15]. Mean heart rate (HR), RSA, and PEP values were computed for each subject across each minute during the tasks. All minutes during tasks were used. For the baseline and the last resting period after all tasks, the mean of 3 min (minutes6, 7, and 8) was used. Reactivity scores were computed by subtracting the initial baseline average value from average task value separately for each task. Recovery scores were computed separately for each task by subtracting the initial baseline average value from the average value during each resting period after tasks. The data analysis is described in more detail elsewhere [11, 12].

Statistical Analyses

No gender×novelty seeking group interactions on cardiac measures were found when gender, novelty seeking group, and age adjustment were included in univariate analyses of baseline, reactivity during different tasks, or recovery. Therefore, all analyses were conducted for men and women in combination. Baseline differences in autonomic cardiac activity (HR, RSA, and PEP) were tested with age- and gender-adjusted univariate analysis procedure with novelty seeking group as the between-subject factor. The task data were analyzed by age- and gender-adjusted general linear model (GLM) repeated-measures procedure with novelty seeking group as the between-subject factor. Analyses of each physiological variable (i.e. ΔHR, ΔRSA, and ΔPEP) included one within-subject factor, i.e., phase (four levels: mental arithmetic, reaction time task, speech preparation, and speech delivery). The recovery data were also analyzed by age- and gender-adjusted GLM repeated-measures procedure similarly as reactivity. In the recovery analyses, there were only three levels as there were no separate resting period after speech preparation.

We further analyzed HR, RSA, and PEP reactivity during each task and HR, RSA, and PEP recovery after each task with the GLM univariate procedure with novelty seeking group as the between-subject factor and with age and gender adjustments. All analyses were conducted with SPSS for windows software (version 15.0).

Results

Stimulus Provoked Reactivity

Table 1 presents the means and standard deviations (SD) and differences between baseline and tasks for physiological measures. In all subjects, HR was significantly higher during

Table 1 Means and SD of cardiac measures during the resting periods and tasks (n=29)

Phase	HR (bpm)			RSA (log ms^2)			PEP (ms)		
	Mean	SD	Differences[a]	Mean	SD	Differences[a]	Mean	SD	Differences[a]
Baseline	70.9	10.7		2.84	0.32		96.7	10.8	
Tasks									
Mental arithmetic	85.7	19.0	$t(28)=5.66$***	2.69	0.35	$t(28)=-2.37$*	85.2	11.4	$t(28)=-5.29$***
Reaction time	76.2	17.5	$t(28)=2.42$*	2.88	0.26	ns	86.7	12.2	$t(28)=-5.20$***
Speech preparation	88.1	16.4	$t(28)=8.57$***	2.74	0.32	ns	85.0	8.6	$t(28)=-5.81$***
Speech delivery	93.2	19.5	$t(28)=8.11$***	2.76	0.32	ns	82.1	11.4	$t(28)=-8.29$***
Resting periods after tasks									
Mental arithmetic	68.6	11.9	$t(28)=-2.66$*	2.90	0.26	$t(28)=2.17$*	98.4	9.6	ns
Reaction time[b]	71.7	13.4	ns	2.90	0.26	ns	96.5	10.2	ns
Speech task	72.1	12.3	ns	2.83	0.25	ns	100.2	10.2	$t(28)=2.71$*

*$p<0.05$, **$p<0.01$, ***$p<0.001$

[a]Differences between the baseline and tasks and between baseline and resting periods

[b] n=28 for PEP during resting period after reaction time task

all tasks compared to the baseline level. RSA was significantly lower during mental arithmetic than during baseline. PEP was significantly lower during tasks than during baseline, whereas PEP during last rest was higher than during baseline.

High and Low Novelty Seeking Groups and Cardiac Reactivity and Recovery

The age- and gender-adjusted repeated-measures analyses that included all task conditions did not show any differences in reactivity between high and low novelty seeking groups for HR, RSA, or PEP ($p>0.477$). Furthermore, univariate analyses adjusted for age and gender showed that high and low novelty seeking groups did not show any differences in HR, RSA, and PEP in baseline values or in reactivity in response to each task ($p>0.125$, for all associations).

The age- and gender-adjusted repeated-measures analyses that included recoveries after all three tasks showed that the high novelty seeking group had a better HR recovery ($F(1,25)=5.567$, $p=0.026$, $\eta^2=0.182$). There were no differences in PEP and RSA recoveries in these analyses ($p=0.347$ and $p=0.133$, respectively).

Univariate analyses also revealed significant differences in recovery between high and low novelty seeking groups. The high novelty seeking group had a better RSA recovery ($F(1,25)=4.665$, $p=0.041$, $\eta^2=0.157$) after the last task, i.e., speech task. Furthermore, the high novelty seeking group had a better HR recovery ($F(1,25)=12.706$, $p=0.002$, $\eta^2=0.337$) after reaction time task. HR recovery after mental arithmetic task was marginally significantly better in the high novelty seeking group ($F(1,25)=3.074$, $p=0.092$, $\eta^2=0.109$). There were no other significant differences in HR, PEP, or RSA recovery between the groups after any task ($p\geq0.166$, for all associations). To take into account the multiple analyses, the critical alpha value of 0.05 was divided by three (the number of physiological measures), which resulted in new alpha of 0.017. According to this criterion, only the association between novelty seeking group and HR recovery after reaction time task remained significant.

Discussion

The present findings did not reveal differences in stress-induced cardiac reactivity between persons with high and low novelty seeking. However, after the experimental challenge, the high novelty seeking group tended to show better recovery, which is likely to be parasympathetically mediated. These results indicate that the association of higher novelty seeking to coronary heart disease risk factors may not be mediated by cardiac stress reactivity or recovery.

It is important to note that as Cloninger's model does not provide clear hypotheses on the association between temperament dimension and cardiac reactivity and recovery, the current analyses are somewhat exploratory in nature. Cloninger [2] has described novelty seeking continuum by dividing it to seven categories: highest 1% and lowest 1% (named severely high and severely low), the next 6% in the high and in the low end (named moderately high and moderately low), and three middle categories. Our participants represented the highest 6% and lowest 5% of novelty seeking selected from over 2,000 participants, which greatly strengthens the power of the analyses. However, the number of participants was relatively small and, therefore, these preliminary observations need to be replicated and the future studies should also include moderate level of novelty seeking to be able to examine linearity and to exclude the possibility of a U-shaped association. Most of the current associations were attenuated to nonsignificance when the multiple analyses were taken into account. However, we found several associations pointing to the same direction which gives credibility to our results.

In conclusion, the current results suggest that the association of high novelty seeking to coronary heart disease risk factors is not likely to be mediated by cardiac stress reactivity. Furthermore, our results suggest that, compared to low novelty seeking persons, high novelty seekers may be more stress resilient as a result of their better cardiac stress recovery. Because of our small sample size and multiple testing, significant results were finally shown only for HR recovery after reaction time task although several other nearly significant associations were found. The current results are preliminary in nature and need replication in larger samples.

Acknowledgements This study was supported by the Academy of Finland (grants 111056 and 124399 for L.K.-J.), the Research Funds of the University of Helsinki (project no 2106012 for L.P.-R.), Finnish Graduate School of Psychology (P.M.), Signe and Ane Gyllenberg foundation (L.K.J. and M.H.), Yrjö Jahnsson foundation (L.K.J. and M.H.), and Alfred Kordelin Foundation (P.M.).

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