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Autonomic Nervous System Activity in the Context of the 'Big Five' Personality Model

Aktivita autonómneho nervového systému v kontexte osobnostného modelu Big Five

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Abstrakt

Variabilita srdcovej frekvencie (HRV) je v súčasnosti považovaná za významný indikátor funkcie autonómneho nervového systému (ANS). Kým vysoké hodnoty HRV sú spojené s dobrou adaptabilitou ANS, znížené HRV môže byť negatívnym prognostickým faktorom niektorých kardiovaskulárnych ochorení. Cieľom príspevku bolo preskúmať vzťah HRV a osobnostného modelu Big Five. Úroveň osobnostných premenných sme zisťovali pomocou dotazníka NEO-FFI a HRV bolo získané z 5-minútových okien pokojových EKG záznamov. Výsledky odhalili pozitívny vzťah medzi extroverziou a HRV a svedomitosťou a HRV a negatívny vzťah medzi neuroticizmom a HRV. Tieto zistenia poukazujú na to, že vysoké skóre svedomitosti a extroverzie je spojené s vyšším HRV a potenciálne nižším rizikom vzniku kardiovaskulárnych chorôb a naopak vysoké skóre neuroticizmu súvisí s nižším HRV a môže byť považované za potenciálnu kardiovaskulárnu záťaž.

Kľúčové slová: osobnosť, big five, variabilita srdcovej frekvencie.

Abstract

Heart rate variability (HRV) is currently considered to be a relevant indicator of the autonomic nervous system (ANS) function. While high HRV is associated with good ANS adaptability, reduced HRV has been established as a significant cardiovascular risk factor. HRV is affected by several factors, such as age, gender, body mass index (BMI), circadian changes, body position, respiratory and also psychosocial factors, e.g. mental stress or personality. The purpose of the present paper is to identify and explore the relationship between HRV and the Big Five personality model. Previous studies have suggested associations between HRV and some of the Big Five traits, but the results are less comprehensive; they exclude some of the personality dimensions or HRV measures. The main aim of this study is to bring some clarity into the area using the full version of the Big Five personality

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model and employing time (HR, SDNN, RMSSD), frequency (HF, LF), and also nonlinear measures (SD1, SD2) of HRV. A total of seventy-eight healthy subjects (63 women, 15 men) reported to be free of cardiovascular or neurological load and were not using any medication that would interfere with cardiovascular or autonomic activity. All subjects signed an informed consent form prior to participating in the study. They all completed the NEO-FFI questionnaire and were connected to portable two-electrode ECG devices. The subjects were monitored in the sitting position under resting conditions, in a group. HRV was obtained from a short-term, 5-minute time window of rest ECG records. The HRV analysis was performed using publicly available software – Kubios HRV. The results showed that extraversion was correlated positively with many of the HRV variables (SDNN, RMSSD, LF, HF, SD1 and SD2) which refer to high HRV. By contrast, high neuroticism exhibited reduced HRV, increased mean HR and decreased RMSSD and HF, which indicates a lower cardiac vagal component of HRV. Significant correlations were also found between conscientiousness and HRV (negatively with mean HR and positively with RMSSD, HF and SD1), which indicates increased parasympathetic activity and higher HRV. The relation between autonomic markers and conscientiousness is still largely unexplored and there are no studies linking autonomic regulation to conscientiousness. Therefore, the present findings reveal valuable and novel insights into the relationship between conscientiousness and HRV. There were no significant correlations between openness to experience and HRV, and between agreeableness and HRV. In conclusion, this study clearly indicates that specific personality traits, such as neuroticism, extraversion and conscientiousness are associated with autonomic regulation expressed though HRV. Moreover, the findings suggest that high conscientiousness and extraversion are associated with high HRV and potentially lower risk of cardiovascular disease, and by contrast, high neuroticism correlated with reduced HRV and could be potentially considered as a cardiovascular risk. The results are also useful in psychological practice because relations between HRV and personality might provide physiological indices that are potentially suited to personality assessment.

Keywords: personality; big five; heart rate variability.

Introduction

Heart rate variability (HRV) is the variation between consecutive heart beats and represents a reliable measure of the autonomic nervous system (ANS) function and its responsiveness. Changes in the HRV patterns can be used as a sensible predictor of health involvements. While higher HRV is associated with good ANS adaptability, reduced HRV has been established as a significant cardiovascular risk factor and is associated with increased morbidity and mortality (Umetani, Singer, McCraty, & Atkinson, 1998). Variations in heart rate can be calculated and evaluated by time-domain, frequency-domain and nonlinear analysis. The time-domain analysis provides information about interbeat (RR) intervals variation and is considered to be the simplest way to calculate and assess HRV. It evaluates HRV as a whole, as opposed to the frequency-domain or spectral analyses, which focus on dynamic and frequency components of HRV. The most commonly used indices of the time-domain are mean HR (or BPM, beats per minute), SDNN (standard deviation of RR intervals) and RMSSD (the root mean square successive differences in milliseconds). SDNN is a measure of heart rate oscillation and reflects total variability during the recording period. RMSSD is sensitive to fluctuations in the respiratory frequency range and

is used as an index of vagal cardiac control (Task Force of the European Society of Cardiology, 1996). The power spectrum of the heart beats interval consists of two main components: a low frequency (LF) band in the range between 0.04 and 0.15 Hz, and a high frequency (HF) band between 0.15 and 0.4 Hz (Kuusela, 2013). The HF band is thought to be indicative of parasympathetic activity because the heart responds to parasympathetic stimulation of the sinus node much more quickly than it does to sympathetic stimulation. It usually corresponds to HRV changes related to the respiratory cycle and can be increased by slow, deep breathing (about 6 breaths per minute); (Bailón, Laguna, Mainardi, & Sornmo, 2007). The LF band is under the influence of both parasympathetic and sympathetic systems and is associated with the activity of baroreceptors (Kuusela, 2013). A widely used nonlinear method is the Poincaré plot, which represents a plot of RR intervals against their successive RR intervals. This visual technique provides two important quantities, SD1 and SD2. SD1 is a measure of rapid changes in RR intervals, so it is considered a parasympathetic index of sinus node control (Mourot et al., 2004). SD2 is influenced by both parasympathetic and sympathetic tones (De Vito, Galloway, Nimmo, Maas, & McMurray, 2002).

In general, the HRV is affected by several factors, such as age, gender, body mass index (BMI), circadian changes, body position, respiratory and also psychosocial factors like mental stress or personality (Ventura & Reisman, 2000; Voss, Schroeder, Heitmann, Peters, & Perz., 2015). Studies focusing on the association between the Big Five personality model and ANS activity are interested in investigation related mainly to neuroticism. Several studies have found out that increased neuroticism is linked to stronger sympathetic responses to stressors (Čukić & Bates, 2015; Drabant et al., 2011; Norris, Larsen & Cacioppo, 2007; Riese et al., 2007; Vogeltanz & Hecker, 1999) and greater cardiovascular reactivity (Muth, Koch, & Stern, 2000). The relationship between HRV and other Big Five factors is less clear and consistent. Zohar, Cloninger and McCraty (2013) found that openness is negatively correlated with HRV parameters which indicate both lower sympathetic activity and lower parasympathetic activity. Low activity for both ANS branches suggests that HRV is only weakly regulated in people high in openness. Conversely, other studies did not reveal any significant relationships between openness and HRV (Daly, Delaney, Doran, Harmon, & MacLachlan, 2010; Silvia, Jackson, & Sopko, 2014; Sloan et al., 2017). Higher baseline HRV was discovered in connection with high extraversion and agreeableness (Daly et al., 2010; Oveis et al., 2009). The relationship between HRV and conscientiousness has not been examined directly, but there is evidence regarding low conscientiousness as a risk factor for stroke and coronary heart disease mortality (Martin, Friedman, & Schwartz, 2007; Terracciano et al., 2009). Therefore, we hypothesize that this personality trait could be positively associated with HRV.

The purpose of the present study is to investigate the relationship between the Big Five personality traits and resting HRV indices in healthy young adults. We want to explore whether specific personality traits are associated with different HRV patterns over the course of the baseline rest condition. Previous studies have suggested associations between HRV and some of the Big Five traits, but results are less comprehensive and ambiguous, with deficiencies such as the exclusion of some personality dimensions or measures of HRV. Therefore, our aim is to bring some clarity into this field using a full version of the Big Five personality model and employing time, frequency and nonlinear measures of HRV. Moreover, our main hypothesis is that higher HRV, which indicates greater self-regulation and flexibility, will be associated with lower neuroticism scores and higher scores across the remaining four Big Five factors.

Methods

Subjects

The research group initially consisted of 80 healthy subjects (65 women, 15 men) with the mean age of 21 years (from 19 to 36). All subjects were second-year psychology undergraduate students from the Comenius University in Bratislava. Two subjects were excluded for a lack of electrocardiogram (ECG) data or poor quality and inaccurate ECG recordings. The final number of subjects was 78 (63 women, 15 men), and they took part in the study in exchange for course credits. The subjects were instructed to consume no caffeine and nicotine for three hours and no alcohol for twelve hours before the ECG measurement (Laborde, Mosley, & Thayer, 2017). They reported to be free of cardiovascular or neurological load and were not taking any medication that would interfere with cardiovascular or autonomic activity. All subjects signed an informed consent form prior to taking part in the study.

Psychological measurements

The subjects' personalities were assessed using the NEO-FFI (Costa & McCrae, 1992). This 60-item self-report scale measures the five major factors of personality: neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness. The subjects were asked to indicate, on a five-point scale, whether each statement was true of them. They marked each item on a 5-point scale (1 = strongly disagree, 5 = strongly agree).

HRV assessment

The HRV data were recorded using portable FAROS 90° two-electrode ECG devices. During these ECG measurements, subjects were monitored in the sitting position under resting conditions, in a group. We collected 6-minutes ECG recordings, from which 5-minute time windows (standardized short-term recordings according to Task Force of the European Society of Cardiology, 1996) were selected for HRV analysis in the publicly available software Kubios HRV. HRV was assessed by time domain (HR, SDNN, RMSSD), spectral analysis (HF, LF) and the Poincaré plot (SD1, SD2).

Statistical analysis

The statistical analysis was performed with the IBM SPSS Statistics version 23.0 for Windows. After the Kolmogorov–Smirnov test had confirmed that our data did not show a normal distribution, nonparametric analysis was selected. Relationships between the personality trait score and HRV indexes were assessed using the Spearman's correlation coefficient. A P value of less than 0.05 was considered to indicate statistical significance.

Results

Cronbach's alpha was calculated for each factor of the Big Five, with satisfactory coefficients obtained for neuroticism (α=0,86), extroversion (α=0,85), openness (α=0,78), agreeableness (α=0,83), and conscientiousness (α=0,91).

Descriptive data for the Big Five dimensions and HRV variables are reported in Table 1. We examined the correlations between all primary HRV variables and selected personality variab-

les. Table 2 presents correlation coefficients between HRV parameters and personality traits in baseline condition. We expected that consideration of several HRV variables and personality variables would help to clarify the interpretation of the complex relationships between personality and autonomic regulation. Neuroticism was correlated positively with mean HR and negatively with RMSSD and HF band. Extraversion was correlated positively with many of the HRV variables (SDNN, RMSSD, LF, HF, SD1 and SD2) and negatively with mean HR. Significant correlations were also found between conscientiousness and HRV (negatively with mean HR and positively with RMSSD, HF and SD1). There were no significant correlations between openness to experience and HRV, and between agreeableness and HRV.

Table 1 Descriptive statistics of the Big Five dimensions and HRV variables

Variable	N	Mean	SD
neuroticism	78	22,5	8,7
extraversion	78	27,2	8,5
openness to experience	78	32,9	7,2
agreeableness	78	31,4	7,6
conscientiousness	78	30,6	9,4
meanHR	78	85,0	11,2
SDNN	78	50,6	16,6
RMSSD	78	32,6	15,7
LF_log	78	2,9	0,3
HF_log	78	2,6	0,5
SD1	78	23,3	10,8
SD2	78	67,4	21,8

Table 2 Spearman correlations between dimensions of the Big Five and HRV indices in baseline condition

	meanHR	SDNN	RMSSD	LF_log	HF_log	SD1	SD2
neuroticism	,308**	-,176	-,225*	,014	-,211*	-,163	-,164
extraversion	-,290**	,295**	,341**	,259*	,273*	,343**	,290*
openness to experience	-,026	,164	,089	,170	,049	,078	,175
agreeableness	-,032	-,158	-,117	-,121	-,110	-,103	-,161
conscientiousness	-,318**	,127	,274*	,086	,416**	,297**	,096

Abbreviations: meanHR: mean heart rate, SDNN: standard deviation of the normal to normal interval, RMSSD: square root of the mean squared differences of successive normal to normal intervals, LF: low frequency, HF: high frequency, SD1: standard deviation of the instantaneous RR variability, SD2: standard deviation of the continuous or long term variability of the heart rate. *p<0.05; **p<0.01

Discussion

The aim of the present study was to investigate the relationships among the Big Five personality model and baseline HRV indices. We noted significant associations between HRV and three

dimensions of the Big Five model: neuroticism, extraversion and conscientiousness. Extraversion was correlated positively with many of the HRV variables (SDNN, RMSSD, LF, HF, SD1 and SD2) which refer to high HRV. By contrast, high neuroticism exhibited reduced HRV and decreased RMSSD and HF, which indicates lower cardiac vagal component of HRV. The present findings provide additional support for the results of several other studies which showed reduced HRV in neuroticism and higher HRV in extraversion (Daly et al., 2010; Oveis et al., 2009; Riese et al., 2007). On the other hand, no significant correlations were found between openness and HRV, and between agreeableness and HRV. These results are contrary to our expectation that HRV would show positive correlation with openness and agreeableness. The findings of previous studies are also inconsistent, therefore future research should use a more extensive and heterogeneous sample and repeated ECG recordings, which are more stable and resistant to situational factors such as sleep quality or emotional state.

The link between HRV and extraversion and neuroticism has been hypothesized and investigated more frequently in the literature than the link between HRV and other Big Five personality traits (conscientiousness, openness to experience or agreeableness). Considering that conscientiousness may have a great influence on health (Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007) and predicts greater longevity (Friedman, Kern, Hampson, & Duckworth, 2014), we hypothesized that this personality trait would be positively associated with HRV. The data confirm this hypothesis and indicate a significant relationship between conscientiousness and HRV. Significant positive coefficients were noted with RMSSD, HF and SD1 as well as negative correlation with mean HR, which indicates increased parasympathetic activity and higher HRV. The relation between autonomic markers and conscientiousness is still largely unexplored and to the best of our knowledge there are no studies linking autonomic regulation to conscientiousness. As a result, the present findings reveal valuable and novel insights into the relationship between conscientiousness and HRV.

It is assumed that personality may affect emotional stress which interferes with the autonomic processes implicated in cardiovascular changes (Carpeggiani et al., 2005). Our results support the idea; furthermore, we suggest that neuroticism, extraversion and conscientiousness are connected with HRV and also the cardiovascular risk profile. Moreover, Campbell-Sills, Cohan and Stein (2006) identified subjects who score low on neuroticism and high on extraversion and conscientiousness as resilient personality types. The given resilience could be psychological as well as physiological.

The present results are also useful in psychological practice because relations between HRV and personality might provide physiological indices that are potentially suited to personality assessment. So far, personality research has relied predominantly on personality questionnaires, whose advantage is that they are capable of obtaining the attitudes and behaviors of an individual. However, these questionnaires are confronted with several problems, such as socially desirable responding, inaccuracies in self-perception, self-favoring tendencies, or self-deception (Cervellione, Lee, & Bonanno, 2009; Pauls & Stemmler, 2003). Physiological indices of personality could be objective because they can hardly be influenced voluntarily by an individual (although they may be influenced by factors unrelated to personality).

The present study had several limitations that may have influenced the results. Firstly, the sample size was modest. Secondly, the sample was drawn from psychology students, which in turn may have affected the results of the self-report questionnaire. In future research, we

recommend verifying the link between personality and physiology with a more extensive and heterogeneous sample. As mentioned in the introduction, HRV is affected by many factors, and this could also have played a role in our HRV measurement. Despite the fact that we controlled the presence of various diseases and other influences like alcohol or caffeine, relatively moderate test-retest reliability of the HRV measures renders HRV measures suboptimal for the assessment of personality aspects (this is partly due to HRV being influenced, for example, by the breathing rate, the circadian rhythm, emotions, mood or stress); (Task Force of the European Society of Cardiology, 1996). So, in future research, we suggest requesting more information by using a questionnaire or checklist, and control as many factors as possible.

The results of this study require replication. However, they suggest an interesting connection between personality traits and autonomic function. The regulation of cardiorespiratory functioning through the autonomic nervous system may be an important way by which personality jointly influences the physical, mental and social aspects of health.

Conclusion

This study clearly indicated that specific personality traits, such as neuroticism, extraversion and conscientiousness are associated with autonomic regulation expressed though HRV. Moreover, the study suggests that high conscientiousness and extraversion are associated with high HRV and potentially lower risk of cardiovascular disease and, by contrast, high neuroticism correlated with reduced HRV and could be potentially considered as a cardiovascular risk.

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