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Exploring the autonomic correlates of personality

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ABSTRACT

The aim of this study was to investigate the relationship between personality and resting heart rate variability (HRV) indices. Healthy volunteers ($n = 106$) completed a 240-item Big Five personality inventory, the state/Trait Anxiety inventory, and a ten minute electrocardiographic recording. Time and frequency domain estimates of HRV were derived from the cardiac time series and related to the Big Five dimensions of personality, to personality types extracted from a cluster analysis, and to Trait Anxiety. Frequency domain measures of HRV (HRV-HF, LF/HF) were associated with specific dimensions of personality, but significance was not noted for the time domain measure (STD-RR). Furthermore, distressed personality types exhibited significantly greater autonomic imbalance (LF/HF) than other personality types. However, significance was not noted for the time domain measure (STD-RR). These results can be explained with reference to a contemporary model of neurovisceral integration.

1. Introduction

Investigating the association between autonomic processes and personality is appropriate given that maladaptive autonomic responses have been linked to inflexible executive function, counterproductive coping strategies (e.g., avoidance), and high levels of arousal (Eysenck, 1967; Koelsch et al., 2012). Sympathetic over-arousal has been connected with various psychological disorders including anxiety (Melzig et al., 2009), depression (Rottenberg, 2007), attention deficit hyperactivity disorder (Lackschewitz et al., 2008), and posttraumatic stress disorder (Hauschildt et al., 2011). Thus there is an implied link between autonomic factors and personality, as classification systems categorizing psychological disorders typically describe symptoms occupying the extreme poles of personality dimensions.

Thayer and colleagues (e.g., Thayer and Brosschot, 2005; Saus et al., 2012) have proposed a neurovisceral integrative model of dynamic autonomic regulation that provides a fresh way of understanding personality in terms of autonomic function. Their model consists of a variety of sparsely distributed cortical and subcortical structures (the so-called central autonomic network (CAN)) that have roles in affective, social, attentional, executive, and motivational behavior (Thayer and Lane, 2009; Riganello et al., 2012). According to this model, the amygdala is under constant inhibition via GABAergic projections from the prefrontal cortex, giving fast, flexible, and appropriate responses to both novel and familiar stimuli. During heighted stress the prefrontal cortex becomes hypoactive and the amygdala disinhibited, resulting in increased cardiac arousal by a rapid release of the heart from vagal inhibition, and then by sympathetic processes. These moment-by-moment autonomic influences on the heart can be indexed by Heart Rate Variability (HRV), with higher HRV viewed as markers of flexible responding and the ability to self-regulate (Ode et al., 2010).

A study investigating the electrophysiological correlates of psychopathy in prison inmates demonstrated that effective inhibitory processes (as measured by cognitive tasks) were related to both high HRV and high levels of interpersonal skills such as superficial charm, manipulation, and pathological lying (Hansen et al., 2007). The authors argued that their findings consistently linked components of the CAN (i.e., HRV and cognitive inhibition) to personality traits. In this scheme, individuals possessing high HRV respond to his/her environment with appropriate levels of arousal, avoiding unnecessary sympathetic-mediated cycles of inflexible over-arousal (a characteristic of Neuroticism). In relation to the CAN it can be deduced that HRV will be positively related to those personality traits associated with flexible responding and broadening response alternatives to situational input (Extroversion, Openness, Agreeableness, Conscientiousness), but negatively associated to the maladaptive trait of Neuroticism, which is characterized by the inability to self-regulate.

Few studies have directly examined the relationship between HRV and personality, and findings are inconsistent. Bleil et al. (2008) and Miu et al. (2009) both reported negative relationships between HRV and Trait Anxiety, the latter a component of Neuroticism. Ode et al. (2010) reported that HRV was not associated with Neuroticism, though only used a brief ten-item scale to represent the more multifactorial construct of Neuroticism. Carpeggiani et al. (2005) reported only one positive correlation between eight HRV measures and Cattell's 16

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personality factors (insecurity and tension). Using the Tridimensional Personality Questionnaire, Huang et al. (2013) found few significant relationships between five HRV indices and 15 personality subscales, even when males and females were examined in isolation, with only a 'harm avoidance' subscale returning a significant negative correlation. Additionally, they found a moderate negative relationship between depression (also a facet of Neuroticism) and HRV, but only for males. Schweiger et al. (1998) related aspects of personality to a single measure of HRV and found no significant associations, while Cukić and Bates (2014) reported negative associations between baseline HRV and Openness.

In this study we investigated the relationship between baseline HRV and personality. Existing studies present inconsistent findings, with personality often haphazardly measured, personality traits but not personality types investigated, small sample sizes risking Type II errors, exclusion of personality dimensions other than Neuroticism, single measures of HRV, and without theoretical guidance. The current study uses a 240 item version of the Big Five personality model, takes both personality traits and types into account, utilizes a relatively large sample, and employs both time and frequency domain measures of HRV. Specifically, it is hypothesized that higher HRV, indicative of either greater self-regulation or flexibility, will be associated with lower Neuroticism scores and higher scores across the remaining four Big-Five factors.

2. Materials and methods

2.1. Participants

Data were collected from 106 postgraduate students or members of staff at the Auckland University of Technology's Faculty of Health. A total of 39 male and 67 female non-smoking participants provided data, with a mean age of 34.74 (±13.34) years. Participation was voluntary, and a shopping voucher was given to each participant on completion of the research. Participants were all non-smokers and reported excellent health. The university ethics committee approved all measures and procedures in accordance with the Declaration of Helsinki for human studies.

2.2. Procedure

Participants were instructed not to consume caffeine nor engage in strenuous physical activity in the two hours prior to arriving at the laboratory. Upon presentation at the laboratory on testing day, participants were briefed on the nature of the research and, if willing to continue, were asked to sign an informed consent form. The research began with the administration of a number of psychometric scales, all completed in isolation. During the recording of electrocardiograms (ECG) the participants were seated in a comfortable arm-chair located in a quiet laboratory, and were asked to remain as still as possible for the duration of the recording. The ECG was recorded for 10 min during conditions of uncontrolled respiration.

2.3. Physiological measurements

Cardiac signals were measured continuously using a 24-bit Nexus 10 (v.2) unit configured to sample at 2048 Hz, twice the recommended rate (Task Force of the European Society of Cardiology and the North American Society of Pacing Electrophysiology, 1996). Following thorough cleaning of the target areas with isopropyl alcohol skin cleansing swabs, three disposable silver–silver chloride (Ag/AgCl) electrodes filled with Redux electrolyte were positioned in a triangular chest configuration (i.e., standard Lead II placement). All recordings were undertaken between 11:00 AM and 2:00 PM. No corrections for respiratory factors were implemented as baseline ECGs collected at rest are not vulnerable to respiratory artifacts (Grossman and Kollai, 1993).

Pre-processing of the ECG, removal of ectopic beats, identification of QRS complexes and the determination of interbeat intervals were performed using ECGLab (Carvalho et al., 2003). Time domain and frequency domain HRV metrics, calculated using Kubios HRV (v.2) analysis software (Tarvainen and Niskanen, 2008), were selected as an indirect measure of autonomic influences on the heart. As the parasymatic system is responsible for most of the variation in the interbeat interval (Porges, 1997), greater HRV is thought to reflect greater parasympathetic dominance, and so HRV is considered a non-invasive index of vagal tone, autonomic balance, and autonomic flexibility (Rajendra et al., 2006; Task Force of the European Society of Cardiology and the North American Society of Pacing Electrophysiology, 1996). In the time domain, the standard deviation of the RR intervals (STD-RR), considered a reliable estimate of overall HRV (Berntson et al., 2008), was calculated. In the frequency domain, power spectrum density estimates were obtained for two frequency bands of interest: 0.04 to 0.15 Hz (Low Frequency: LF), and 0.15 to 0.40 Hz (High Frequency: HRV-HF). It is thought that HRV-HF is an estimate of parasympathetic influences on HRV, while LF is thought to reflect both parasympathetic and sympathetic influences (Dishman et al., 2000). The ratio LF/HF is thought to provide a meaningful index of overall autonomic balance (Montano et al., 2009).

2.4. Psychometric scales

Personality was measured using the 240 item NEO Personality Inventory-Revised (NEO-PI-R) (Costa and McCrae, 1992), which assesses all five dimensions of the Big-Five: Neuroticism (N), Extraversion (E), Openness (O), Agreeableness (A), and Contentiousness (C). Each dimension is comprised of six facets of eight items each, which are summed to yield a total score for each dimension. Personality can also be conceptualized at the 'type or prototype' (nominal) level of description. Structural analyses of the Big Five dimensions have been performed to extract personality prototypes, labeled 'Resilient', 'Average', and 'Non-desirable' (e.g., Rammstedt et al., 2004). Resilient types are characterized by lower than average Neuroticism and higher than average scores across the other four dimensions of the Big Five, with an emphasis on Extroversion. Average types have average-to-moderate Neuroticism and mediocre scores across the other four dimensions. Non-desirable, or 'Distressed',[1] types have higher than average Neuroticism scores, and lower than average scores on all other factors, with the emphasis on Introversion.

State and Trait Anxiety was measured using the State-Trait Anxiety Inventory (STAI: Spielberger, 1983), which requires respondents to read 40 statements and respond to each by circling the number, on a four-point Likert scale, that best reflects the statements' perceived relevance, either in "this moment" (State Anxiety) or "generally" (Trait Anxiety).

2.5. Statistical analyses

Scale reliability was assessed using Cronbach's alpha (α_c). For the trait analyses, the association between continuous personality measures (NEO-PI(R) and Trait Anxiety) and baseline HRV (logarithmically transformed) indices were investigated using partial correlation coefficients controlling for age and mean heart rate, both of which have been shown to be related to measures of HRV and are considered confounding variables (Kupari et al., 1993). High collinearity was observed between the two STAI scales ($r = 0.854$, $p < 0.001$). Trait Anxiety is a more temporally stable construct relative to State Anxiety, and in this way is more similar to the Big Five dimensions. For this reason, Trait

[1] The term 'non-desirable' is inappropriate, as it is overtly judgmental. Better would be to incorporate Denollet's (2005) Type-D personality with the prototype names suggested by Rammstedt et al (2004), which would result in: Resilient, Distressed, and Average Personalities.