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Personality and physiological reactions to acute psychological stress

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ABSTRACT

Stable personality traits have long been presumed to have biological substrates, although the evidence relating personality to biological stress reactivity is inconclusive. The present study examined, in a large middle aged cohort ($N = 352$), the relationship between key personality traits and both cortisol and cardiovascular reactions to acute psychological stress. Salivary cortisol and cardiovascular activity were measured at rest and in response to a psychological stress protocol comprising 5 min each of a Stroop task, mirror tracing, and a speech task. Participants subsequently completed the Big Five Inventory to assess neuroticism, agreeableness, openness to experience, extraversion, and conscientiousness. Those with higher neuroticism scores exhibited smaller cortisol and cardiovascular stress reactions, whereas participants who were less agreeable and less open had smaller cortisol and cardiac reactions to stress. These associations remained statistically significant following adjustment for a range of potential confounding variables. Thus, a negative personality disposition would appear to be linked to diminished stress reactivity. These findings further support a growing body of evidence which suggests that blunted stress reactivity may be maladaptive.

1. Introduction

It is now commonly known that individuals vary markedly in the way their body reacts to stressful and challenging environmental exposures (Carroll, 1992). Consistent individual differences in stress reactivity have been observed in the hypothalamic–pituitary–adrenal (HPA) axis, as indexed by cortisol, and in the sympathetic–adrenal–medullary (SAM) system, as indexed by cardiovascular activity (Lovallo, 1997). It is also clear that these individual differences have implications for health and behaviour (Carroll et al., 2009; Chida and Steptoe, 2010). For example, greater cortisol and cardiovascular reactivity to acute stress has been associated with increased risk of cardiovascular disease (Carroll et al., 2011a; Chida and Steptoe, 2010; Hamer et al., 2010; Treiber et al., 2003). In contrast, however, recent evidence also implicates diminished cortisol and cardiovascular reactions in a range of adverse health and behavioural outcomes, such as smoking, alcohol dependence, obesity, and depression (Carroll et al., 2009, 2011b). What is less certain is whether individual differences in biological stress reactivity reflect consistent variations in basic human personality traits. Early research on Type A behaviour and stress reactivity proved inconclusive (Carroll, 1992), although there is evidence that one component of the Type A behaviour, hostility, is associated with greater cortisol and cardiovascular reactions to stress, e.g., (Smith et al., 2004). However, this is not a completely consistent finding (Carroll et al., 1997). There is, nevertheless, compelling theoretical reasons for expecting the variations in stress reactivity to map on to individual differences in personality traits; if personality, as has been proposed, affects stress perception (Connor-Smith and Flachsbart, 2007), cognitive stress theories and previous research would suggest it should also affect biological stress reactions (Carver and Connor-Smith, 2010; Dickerson and Kemeny, 2004; Lazarus, 1996).

Recent research on personality has frequently turned to the Big Five trait taxonomy which identifies five broad personality dimensions; neuroticism, agreeableness, openness, extraversion, and conscientiousness (McCrae and Costa, 1987). Each trait has demonstrated high stability for up to 45 year intervals (Soldz and Vaillant, 1999; Terracciano et al., 2006). Neuroticism refers to a tendency toward negative affectivity and an inclination toward impulsive behaviour. Agreeableness connotes a willingness to be helpful and trusting, and to possess a pro-social orientation towards others. Individuals high in openness to experience tend to be imaginative, creative, attentive to inner feelings, prefer variety, and are flexible in their thinking. Extraversion refers to the inclination to be energetic, sociable, and assertive, and conscientiousness encompasses organization, self-discipline, and determination (McCrae and John, 1992).

Higher neuroticism has been associated with lower cortisol stress reactivity (Kirschbaum et al., 1993; Oswald et al., 2006; Phillips et al., 2005) although it should be conceded that numerous studies reported no association between neuroticism and cortisol reactions to a range of stress exposures (Kirschbaum et al., 1992, 1995; Schommer et al., 1999; Verschoor and Markus, 2011; Wirtz et al., 2007). Nevertheless, in

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support of the evidence suggesting higher neuroticism is linked to blunted physiological stress responses, a meta-analysis of 71 laboratory studies concluded that neuroticism, anxiety, and negative affect tended to be linked to attenuated cardiovascular stress reactivity (Chida and Hamer, 2008), with more recent studies reporting blunted heart rate (HR) (Hughes et al., 2011) and diastolic blood pressure (DBP) stress responses (Jonassaint et al., 2009) in highly neurotic individuals. Again, however, a number of studies have also reported no association between neuroticism and cardiovascular stress reactions (Hutchinson and Ruiz, 2011; Kirkcaldy, 1984; Schneider, 2004; Stemmler and Meinhardt, 1990; Williams et al., 2009). It is important to note that such null findings between neuroticism and physiological stress reactivity may well have been due to low power (Kirschbaum et al., 1995), restricted range (Schommer et al., 1999; Wirtz et al., 2007) or arbitrary categorization of neuroticism scores (Hutchinson and Ruiz, 2011), examination of anticipatory rather than stress reactions (Verschoor and Markus, 2011), insufficiently provocative stress exposures (Kirkcaldy, 1984; Williams et al., 2009), or a host of other methodological issues (Stemmler and Meinhardt, 1990). Therefore, due to these methodological flaws, evidence may well suggest that high levels of neuroticism are related to blunted biological stress reactivity.

The other personality traits of the Big Five have received far less attention in this context. For agreeableness, null findings have been reported for cortisol (Oswald et al., 2006; Wirtz et al., 2007) and cardiovascular (Williams et al., 2009) stress reactivity. Openness has been reported to show a positive (Oswald et al., 2006), negative (Wirtz et al., 2007), and no (Schoofs et al., 2008) association with cortisol stress reactivity. In the one study we know of examining the relationship between cardiovascular stress reactivity and openness, a negative association emerged for blood pressure reactivity (Williams et al., 2009). Research on extraversion has generally yielded null outcomes for both cortisol (Kirschbaum et al., 1992; Schommer et al., 1999; Wirtz et al., 2007) and cardiovascular (Kirkcaldy, 1984; Vassend and Knardahl, 2005; Williams et al., 2009) stress reactivity. Finally, null findings also characterise the few studies that have examined conscientiousness and cortisol (Oswald et al., 2006; Wirtz et al., 2007) and cardiovascular (Williams et al., 2009) reactions to stress.

Previous research on personality and biological stress reactivity suffers from a number of limitations. Among them are small sample sizes (Kirschbaum et al., 1995; Oswald et al., 2006; Wirtz et al., 2007), the predominance of young student samples (Kirschbaum et al., 1992; Verschoor and Markus, 2011; Williams et al., 2009), restricted range of trait scores (Schommer et al., 1999; Wirtz et al., 2007), dichotomised trait variables (Kirkcaldy, 1984), and the failure to adjust statistically for a range of possible confounding variables (Williams et al., 2009; Wirtz et al., 2007). The aim of the present study was to re-examine, in a large middle aged cohort, the relationship between the Big Five personality traits and both cortisol and cardiovascular reactions to a comprehensive stress protocol comprising three acute psychological stress tasks. The nature of the study allowed us to adjust for a number of potential confounders. In addition, examination of the self reported stress task impact will also extend the previous literature, and possibly shed light on the psychological mechanisms linking the personality traits to physiological stress reactions. It was hypothesized that neuroticism would be negatively associated with both cortisol and cardiovascular stress reactivity. Given the paucity and inconsistency of previous research, we had no clear expectations regarding the size and the direction of any association between stress reactivity and the other personality traits that make up the Big Five.

2. Materials and methods

2.1. Participants

Participants were selected from the Dutch Famine Birth Cohort, which comprises 2414 men and women who were born in Amsterdam, The Netherlands, between November 1943 and February 1947. The selection procedures and subsequent loss to follow up have been described in detail elsewhere (Painter et al., 2005). The Dutch Famine Birth Cohort Study was designed to investigate the potential consequences of prenatal exposure to famine on health in later life. It might, therefore, be suggested that population characteristics may hamper generalization of the present analyses. However, this is very unlikely as health effects pertain in the group of people exposed to famine in early gestation (Roseboom et al., 2006). Only 8% of the total study sample and 9.5% ($N = 37$) of the present sample were exposed to famine in early gestation. Nevertheless, we chose to exclude them to prevent any possible contamination. Seven hundred and twenty five of the sample attended a clinic assessment between 2002 and 2004, during which time cortisol and cardiovascular reactions to acute psychological stress were measured. In 2008–2009, participants were asked to complete a questionnaire package which included the Big Five Inventory (BFI) (Denissen et al., 2008). Six hundred and one participants returned the questionnaires. The effective sample size for the present analyses, i.e., cohort members who undertook stress testing and completed the Big Five, was 352 (190 women). The mean (SD) temporal lag between the questionnaire assessment and the stress session was 5.5 (0.6) years. Both arms of study were approved by the local Medical Ethics Committee and carried out in accordance with the Declaration of Helsinki. All participants gave written informed consent. The sociodemographic, anthropometric, health behaviour and medication status characteristics of the effective sample are shown in Table 1.

2.2. Psychological stress testing

The stress protocol has been described in detail elsewhere (de Rooij et al., 2006) and is illustrated in Fig. 1. In short, the stress testing was performed in the afternoon, about an hour after participants had eaten a light lunch. The protocol started with a 20-minute baseline period, followed by three 5-minute psychological stress tests (Stroop, mirror tracing, and speech); the inter-task interval was 6 min. The final task, the speech, was followed by a 30-min recovery period. The Stroop test was a single trial computerized colour–word conflict challenge. After a short introduction, participants were allowed to practice until they fully understood the requirements of the task. Errors and exceeding the response time limit of 5 s triggered a short auditory beep. In mirror tracing, a star had to be traced that could only be seen in mirror image (Lafayette Instruments Corp, Lafayette, IN, USA). Every divergence from the line of the star induced a short beep. In the speech test, participants were told to imagine being accused of pick-pocketing and instructed to give a 3-minute defence of the accusation, which was videotaped. They were given 2 min to prepare their defence. Participants were told that the number of repetitions, eloquence, and persuasiveness of their performance would be marked by a team of communication-experts and psychologists.

Saliva samples were collected using Salivettes (Sarstedt, Rommelsdorf, Germany) at seven time points during the protocol: at 5 and 20 min in the baseline period; at 6 min after completion of the Stroop; at 6 min after completion of the mirror-drawing test; and

Table 1
Characteristics of final sample at clinic assessment ($N = 352$).

Variable	M/N	SD/%
Age (years)	58.23	0.95
Sex (female)	190	52.5
Socio-economic status (ISEI-92)	51.29	13.64
Body mass index (kg/m^2)	28.76	4.90
Alcohol (units of per week)	9.83	15.01
Current smoker	74	20.5
Anti-hypertensive medication	96	26.5
Anti-depressant or anxiolytic	45	12.4

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